

**SVALBARD SCIENCE CONFERENCE 2019**  
**Book of abstracts**

*\*Indicate presenter of the abstract. Please find an alphabetized list over presenters, including abstract numbers, title and mode of presentation at the end of the file.*

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## **Description of the sessions**

### **Session 1 – Setting the stage**

#### **Svalbard is not at the edge of the world but at the centre of the Arctic**

Svalbard is, with its location in the high Arctic and its well developed and accessible infrastructure, an attractive platform for Arctic research. This session will focus on future Svalbard in a pan-Arctic setting. How can we enhance the value of the research undertaken here? How can we encourage high quality science through building and strengthening interdisciplinary and international networks? How to enhance cooperation, data sharing and sustainability? To start the discussions this opening session presents a host of invited speakers and selected talks to inspire and ignite.

What role will a changing Svalbard play in Arctic research in the future?

### **Session 2 – Svalbard > 0°C**

#### **Svalbard is warming at an alarming rate and change will come- but to what?**

The report “Climate in the Svalbard 2100” predicts that if nothing is done to stop the warming the average temperatures in Svalbard could increase as much as 10 degrees by the end of the century. Such a change will have enormous effect on not just on ecosystem functions and services, geohazards and the cryosphere but on society as well. During this session, we want to explore the effects of a temperature increase on Svalbard and the Arctic.

What can your research predict about the future based on the knowledge we have today?

### **Session 4 – Svalbard in the dark**

#### **The dark period is a new frontier in Arctic science.**

The notion that everything shuts down in the dark period has well and truly been abandoned. In several fields the dark season this is the main season. There are algae and ice growing in the sea, animals and rain on land, aurora and black carbon in the atmosphere and people out and about. But working in the extreme conditions of the Arctic winter presents challenges both logistically and scientifically and calls for international and interdisciplinary collaboration. Svalbard is well suited for these studies and in this session, we want to focus on the implications of this newly gained insights into mid-winter processes and how we, together, can solve some of the challenges ahead.

Which new insights have been discovered recently from the metaphorically dark unknown and where will they lead us?

### **Session 5.1 – Toolbox**

#### **Scientific instruments and other tools have always relied on the technological development available at any given time.**

In this session we will focus on which tools that will be important for polar science in the future. Among others we request inputs on new instrumentation and technologies, Communication tools, “Big data” in polar research and integration of different data sources (land and sea based, drones and air, satellites). Both existing and upcoming developments are welcome.

What new tools will Arctic research benefit from in the coming years?

### **Session 5.2 – Long term monitoring**

#### **What can we learn from observations, and do we measure what is required and with adequate precision and geographical coverage?**

Svalbard is a very well-suited location to study both regional and global phenomena. In this session will address ongoing monitoring efforts, and their integration across themes and disciplines.

Observations of meteorology, atmospheric chemistry, biology and oceanography allow the assessment of natural and anthropogenic long-term changes of the environment. The derived data are essential in understanding perturbations of biogeochemical cycles and the associated impacts on ecosystems. Data also form basis for policy response actions. At the same time, long-term monitoring requires commitment and sustained funding, often over many decades, to distinguish short term fluctuations from the general baseline trends.

Can the impact of long-term monitoring in terms of policy response be exemplified?

### **Session 5.3 – An ocean of plastic**

**Plastic pollution can affect all aspects of society and environment in the Arctic and beyond.**

There is a growing number of scientific investigations showing the extent of plastic pollution across the Arctic. This has in turn set off a series of management decisions and policy processes. But are these decisions and processes based on a sound knowledge foundation? What knowledge is needed and what is lacking for science-based management?

What new insights and knowledge can we that work with plastic pollution share among ourselves to gain a holistic understanding?

### **Session 5.4 – Rocks, mud and ice**

**Svalbard is a climate laboratory. The status of the glaciers and the permafrost are important indications of present global climate change**

Svalbard contains a nearly complete archive of the earth's history. An almost complete geological layer series spanning the last 500 mill years places Svalbard on the map as an important reference in a global context. In the rocks making up Svalbard we find the development of life on earth and indications of climate through the earth's history. The cryosphere also serves as a climate archive and indicator at it will respond to a changing climate. There are many interdisciplinary topics related to a changing Arctic, how are the increased fresh-water fluxes from glaciers effecting the marine ecosystem? What are the implications for sea-level change, local isostatic change? What are the effects of snow-cover on the terrestrial ecosystem or on the carbon cycle?

What can Svalbard's past tell about its future?



## **Invited speakers and panel debate participants**

### **Professor Julie Brigham-Grette, University of Massachusetts-Amherst, US NAS Polar Research Board**

Brigham-Grette is a Professor on the Department of Geosciences at UMass-Amherst and Chair of the Polar Research Board, US National Academy of Sciences. She has been conducting research in the Arctic for 40 years mostly in parts of Beringia, western Arctic, including the Bering and Chukchi Seas. For several years Julie and collaborators have run a Research Experience for Undergraduates on Svalbard studying modern processes in front of tidewater glaciers in Kongsfjord.

### **Professor Hanne H. Christiansen, UNIS**

Hanne H. Christiansen is a physical geographer, who has lived and worked in Svalbard since 2002. She is a professor studying periglacial geomorphology, in particular climatic and meteorological control on periglacial landforms, processes and sediments. She works at the University Centre in Svalbard, UNIS, where she is the Vice Dean for Education. She is also the President of the International Permafrost Association.

### **Professor Thomas Hylland Eriksen, University of Oslo**

Thomas Hylland Eriksen is Professor of Social Anthropology at the University of Oslo and the author of many books in various genres, from the scholarly to the polemic, from the textbook to the novel. His research has in recent years focused on implications of accelerated change, and his project "Overheating: The Three Crises of Globalisation" was funded through an ERC Advanced Grant from 2012 to 2017. His most recent books in this area are "Overheating: An Anthropology of Accelerated Change" (2016), "Boomtown: Runaway Globalisation on the Queensland Coast" (2018) and, co-edited with Astrid Stensrud, "Climate, Capitalism and Communities" (2019).

### **Sergei Verkulich, Doctor of Science (geography), chief scientist – head of Department of geography of polar countries, Arctic and Antarctic Research Institute, St. Petersburg, Russia.**

Field of scientific interest: glaciology, environmental changes in polar regions in Late Pleistocene – Holocene. Subjects of investigations: relief, terrestrial quaternary deposits, bottom sediments of lakes and shallow shelf basins.

### **Dr Radovan Krejci, Stockholm University**

Researcher at Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University, Sweden working in the Arctic for more than a decade. His work focuses on experimental studies and process understanding of aerosol-clouds-climate interactions. He is currently chair of the Ny Ålesund Atmospheric Flagship Program.

### **Dr Nuncio Murukesh National Centre for Polar and Ocean Research, India**

I have joined National Centre for Polar and ocean Research in 2008. Currently lead a team to study Arctic Ocean and Atmosphere. Our main "centre of action" is Ny Alesund One of my important responsibility is to maintain the atmospheric laboratory at Gruvebadet, Ny Alesund. My research interest includes the Arctic hydrological cycle and ocean atmosphere interactions. We try to attend to the problems through a combination of observations, reanalysis and models. Currently I serve as

an Atmospheric Working group member in International Arctic Science Council. Apart from practising science, I am always happy to communicate it through various outreach activities.

#### **Dr Ketil Isaksen, Met Norway**

Ketil is a Climate scientist - a permafrost specialist at the Norwegian Meteorological Institute (MET Norway). His primary area of interest and expertise are related to observational based analyses of climate change in mountain regions and in the Arctic, including the application of long-term climate and permafrost monitoring, permafrost thermal response and sensitivity to climate change and extreme events and physical processes related to snow-permafrost interactions. He started his Svalbard career as a student at UNIS in 1995 and have stayed there every year since then for shorter and longer periods. He completed his Ph.D. at the Department of Geosciences, University of Oslo in 2001 at the EU-funded project PACE - Permafrost and Climate in Europe. In 2002 he got a permanent research position at MET Norway at the Climate Division. Since 2012 he has been working as a Senior Researcher at the Research and Development Department at MET Norway.

#### **Professor Marit Reigstad**

Reigstad is a professor in marine ecology at UiT since 2009, and is presently leading the Norwegian collaborative research project *The Nansen Legacy*. This project aims to build a multidisciplinary knowledge basis on the changing climate and ecosystem in the seasonally ice-covered northern Barents Sea and adjacent Arctic Ocean. Reigstads scientific expertise includes productivity, plankton and vertical flux and physical-biological coupling. Reigstad enjoys interdisciplinary collaboration, has participated and lead several Arctic marine research projects.

#### **Professor Jøran Moen, University of Oslo**

Prof. Jøran Moen is currently Head of the Department of Physics at the University of Oslo. Moen received PhD in physics at the University of Oslo in 1994, after which he became Associated professor at the University Center in Svalbard. Since year 2000 he has been professor at the University of Oslo, and Adjunct Professor at the University Center in Svalbard. His field of expertise is space physics; Rocket science. He has organized dozens of auroral and rocket campaigns in Svalbard. He is currently project scientist for the Grand Challenge Initiative-Cusp, a gigantic sounding rocket program.

#### **Per Kyrre Reimert**

Jeg er arkeolog og har fra 1976 arbeidet med feltarbeid, forvaltning, formidling og forskning i Svalbards historie. Fra mai 1998 og ut 2000 var jeg ansatt av Norges Forsknings Råd for å etablere Svalbard Science Forum i Longyearbyen. Jeg skriver nå boken «Okkupasjon av land på Svalbard 1898-1927» sammen med Peter Brugmans og arbeider sammen med Thor Bjørn Arlov i et forskningsprosjektet på UNIS som heter: Swedish-Russian Arc meridian Measurement 1899-1902 (SRAM) RiS 6950.

## **1001 «La Recherche» 1838 and 1839 The first scientific expeditions to Svalbard**

**Per Kyrre Reymert\***

1838 og 1839 the research vessel «*La Recherche*» visited Svalbard. The French science project had international participation in several natural sciences. Painters and drawers documented nature and activities, samples were collected from land and sea and observations documented. The results were published in 26 bind and five collections of 450 art works between 1843-1855. The «*La Recherche*» scientific publications, articles, lectures and several books by the participants for the first time made Svalbard known to the scientific community and the general public. And this was the start of the scientific exploration of Svalbard.

## **1003 Increased shipping in Svalbard waters: local impacts and adaptive responses**

**Julia Olsen\*, Grete K. Hovelsrud, Bjørn P. Kaltenborn**

Nordland Research Institute

This paper presents findings from an explorative study on the consequences of, and response to increasing shipping in the community of Longyearbyen. Historically the shipping activities have been connected to the community's development by covering transportation, supply, mobility and subsistence needs. Nowadays, the area experiences changes in shipping trends, in the form of growth, vessels types and their spatial and temporal distribution. The noticeable changes in shipping development include fishing and marine tourism activities that move northward, and growth in pleasure crafts boats. At the same time, severe weather conditions coupled with the polar night, long distances, and limited Search and Rescue (SAR) capacity present the main limitation for safety operations.

This study presents numerous impacts on communities' livelihoods and their local environment and assesses the community responses to mitigate the negative impacts from the development, while enhancing the positive. Here we underline that the significant growth in shipping activities (particularly in passenger vessels) affects local economy and employment, community livelihoods and has an impact on the natural environment. Using findings from interviews (n=36), we argue that the local engagement of the Longyearbyen community in adaptive responses strengthens local adaptive capacity and presents a supportive mechanism for local shipping governance.

Our theoretical and methodological contributions are relevant for a pan-arctic studies that examines the local impacts from increasing shipping activities. At the same time the study can benefit from integration of materials and data from cryosphere studies (incl. sea ice dynamics), as certain types of shipping operations have a direct connection to the sea ice extent.

## **1005 Disaster-related science diplomacy for Svalbard's future**

**Ilan Kelman\* (1,2), Yekaterina Y. KONTAR (3,4), Patrizia Isabelle DUDA (2)**

(1) University of Agder, Norway; (2) University College London, UK; (3) University of Colorado Boulder, USA; (4) International Union of Geodesy and Geophysics, Germany

Svalbard is a place where significant disaster-related research is conducted for the Arctic. One key example is monitoring, observing, and analyzing environmental data to support prevention (e.g. for snow conditions to update avalanche danger zones) and response (e.g. weather forecasts for search-and-rescue). This scientific work is completed by international and national teams who connect to the pan-Arctic setting such as through the Arctic Council, international scientific cruises and expeditions, and personal networks. Svalbard therefore represents a key case study for examining disaster-related science diplomacy, to determine whether or not conducting collaborative science for addressing disasters can support wider and long-term endeavors in pan-Arctic diplomacy.

Previous experience in disaster-related science diplomacy and other disaster diplomacy work offers possible futures for Svalbard. In particular, investigations of case studies have not shown instances where science created new, lasting diplomacy over the long-term. This includes many examples, including for the Arctic, where scientists became high-level diplomats or politicians, because the individuals' successes and stature emerged from their non-scientific contributions. Past research also details the significant scientific successes emerging from Svalbard-based and pan-Arctic work, but little explicit spillover occurs based on the scientific activities alone. Consequently, caution might be warranted to ensure that Svalbard-related scientific cooperation continues to lead the world, rather than directly seeking positive diplomatic outcomes from the science.

Thus, for Svalbard in the future, questions arise regarding:

1. Whether or not disaster-related science diplomacy should be actively and overtly pursued.
2. How to avoid compromising the quality of the science.
3. Making the best use of Svalbard as a pan-Arctic center for improvements in, and demonstrating the value of, sharing data, building cross-border project consortia, connecting different modes of and players in cooperation, and pursuing science for Arctic sustainability.

## **1006 Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC)**

**Anja Sommerfeld\* (1), MOSAiC Team**

(1) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)

The key element of MOSAiC is the drift of the icebreaker Polarstern frozen into the pack ice over an entire year. MOSAiC is an international initiative under the umbrella of the International Arctic Science Committee (IASC) designed by an international consortium of leading polar research institutes.

Rapid changes in the Arctic lead to an urgent need for more reliable information about the state and evolution of the coupled Arctic climate system. This requires high quality observations and improved modeling over various spatial and temporal scales and a variety of disciplines. Observations of many critical parameters have, to date, not been carried out in the central Arctic for a full annual cycle. MOSAiC will be the first year-around expedition into the central Arctic exploring the coupled climate system. The drift of Polarstern starts in the Siberian sector of the Arctic in Sep. 2019. Around

Polarstern, in an area representing the spatial scale of a typical climate model grid cell, a distributed regional network of observational sites will be established on the sea ice. The ship and the surrounding network will drift with the sea ice drift across the North Pole towards the Atlantic. The focus of MOSAiC lies on in-situ observations of climate processes that couple atmosphere, ocean, sea ice, biogeochemistry and ecosystem. These measurements will be supported by weather and sea ice predictions, and remote sensing operations to aid operational planning and extend the observational results in time and space. The observations will be used for the main scientific goals of MOSAiC: enhancing the understanding of the coupled Arctic climate system and the regional and global consequences of Arctic climate change and sea ice loss. In particular, the observations are needed to advance data assimilation and improve parameterizations of small-scale processes in numerical weather prediction models, sea ice forecasts, and regional and global climate models.

## **1007 The Svalbard Decomposition Map Project**

**Matteo Petit Bon\* (1), Magdalena Wutkowska (2)**

(1) Department of Arctic Biology, University Centre in Svalbard (UNIS); (2) Department of Arctic and Marine Biology, Faculty of Biosciences, Fisheries, and Economics, Arctic University of Norway (UiT)

How will decomposition rates across Svalbard terrestrial ecosystems respond to environmental changes? Climate warming is expected to increase organic matter decomposition in Arctic ecosystems. The vast stocks of C in these regions make this a point of global significance. Here, warming-induced higher decomposition rates may lead to a disproportionately large release of C into the atmosphere, and ultimately create positive feedbacks to the global climate system.

However, this is not a trivial question. First, we need to identify the relative importance of organic matter quality, environmental characteristics, and community of decomposers in driving decomposition rates of Svalbard ecosystems. Second, since these drivers are likely to greatly vary in space, we must encompass a large-scale climatic gradient in order to predict how climate changes may ultimately affect the Svalbard C balance.

**The Svalbard Decomposition Map project calls for collaborations with researchers working in Svalbard and interested in understanding its role in the global C cycle.** This collaborative project will use the recently developed Tea Bag Index® (TBI) method (Keuskamp *et al.*, 2013 – Methods in Ecology and Evolution) for obtaining decomposition data from different sites across Svalbard. This relatively inexpensive method uses two types of tea with contrasting decomposability as standard litter substrate to characterize decomposition processes.

By burying tea bags at different sites, the project aims at (i) identifying the main drivers of litter decomposition across ecosystems found in Svalbard and (ii) using these field observations to model decomposition rates across the whole archipelago. Ultimately, we will be able to (i) identify those areas that will contribute the most to a future release of C in a warmer Arctic and (ii) provide strong statistical relationships that can be used to parameterize future climate system models and refine the role of Svalbard in the global C cycle.



## **1009 Using seasonal variation in zooplankton and predator energy content to expose susceptibility to pollutants in the Barents Sea ecosystem**

**Robynne Nowicki\*, Katrina Borgå, Geir Wing Gabrielsen, Øystein Varpe**

The University Centre in Svalbard, University of Oslo

Climate change is not only altering the Arctic environment, but also its socio-economic position on the global stage. With an increasing interest in ship-based activities, Arctic marine ecosystems risk being exposed to an array of new and intensifying stressors. With exposure to stressors such as pollution in combination with climate change, it is vital to understand their combined effect on representative species. However, the Arctic is well known as a region of amplified seasonality, particularly in terms of food availability, light and subsequent adaptations such as lipid storage. Therefore, it is likely that as an organism's body condition and energy requirements vary throughout the annual cycle, as will its susceptibility to stressors such as pollutants. Through extensive quarterly sampling during several *Nansen Legacy* cruises in the Barents Sea, this study aims to quantify the seasonal changes in species specific energy content, using bomb calorimetry, within and across trophic levels (macrozooplankton and fish). We aim to assess potential "critical windows", i.e. when organisms are in a sub-optimal state and therefore more susceptible to persistent organic pollutants (POPs). We will also evaluate how seasonal energy content and pollutant levels of prey will impact the top-predators in the system, particularly seabirds. In addition, tissue specific samples will be taken for POP concentration, to study seasonal remobilization in key marine organisms. The Barents Sea presents a unique opportunity to study ongoing borealization, allowing a direct comparison between Arctic and Atlantic water masses and species communities. Comparing these species' strategies and potential "critical windows", the varying robustness of these communities against multiple stressor effects can be assessed. Our study can be used to predict changes to species composition and functioning in the future Barents Sea, as well as the functioning of future marine ecosystems across the Arctic.

## **1010 Expanded social science agendas for Svalbard research**

**Mathias Albert\* (1)**

(1) University of Bielefeld

An increased contribution of the social sciences to Arctic research more generally, and to Svalbard research in particular, is often called for (witness a range of statements at the 2017 Svalbard Science Conference). However, it seems that developments in this regard remain slow. In addition, and particularly from the perspective of most researchers from the natural sciences, the contribution of the social sciences is often marginal for their own work at best, and usually related to but two issue areas broadly conceived: On the one hand, the living conditions and social structure changes of people living and communities in the Arctic, including their interactions with changing natural environments. On the other hand, issues of geopolitical interests and conflict, where Svalbard occupies a rather particular role in research in both the field of International Politics and International Law (although admittedly a very marginal one if seen from the 'inside' perspective of these fields).

The present contribution argues that while social science research in the two areas mentioned is worthwhile being pursued and intensified further, there is a deep and persistent gap when it comes

to understanding how and to which degree Svalbard research in the natural sciences is both shaped by cognitive frames that are decidedly influenced by a range of political, economic, and cultural factors; and how, on the other hand, natural science research feeds back into processes that constantly shape and re-shape such cognitive frames. The contribution argues that what an analysis of these cognitive frames requires is an in-depth network and qualitative analysis of Svalbard research (and researchers), in order to gain a better understanding of the complex, yet often overlooked, interplay of (natural science) research and ensuing political agendas.

## **1011 Anthropogenic noise in the Spitsbergen settlements**

**Janusz Piechowicz\* (1), Dorota Czopek (1), Jerzy Wiciak (1)**

(1) AGH University of Science and Technology Krakow

The noise generated by man in the progress of civilization process is present everywhere. Global warming is encourage and conducive to human settlement in the Arctic regions. Longyearbyen is the largest settlement and the administrative center of the Svalbard Islands. However the town has a small population, but there are exist many noise sources. The dominant sources are traffic noise, such as: traffic of light and heavy cars, motorcycles, noise of airplanes and helicopters flying and landing at a nearby airport. In winter, snowmobiles and other vehicles adapted for snow riding become the main source of road noise. Industrial noise is the noise generated by stationary sources, located inside and outside various types of industrial, construction and service facilities. In addition, a large number of visitors increase the noise level associated with tourism.

The variability of acoustic conditions in the Longyearbyen environment was assessed on the basis of 24-hours sound measurements with the use of noise monitoring stations located in several points of the city. To identify the sources of noise and determine their acoustic parameters, the measurements were made directly in the noise sources. This allowed to create Longyearbyen noise maps for day and night time in the winter and summer seasons. These maps have shown that the noisiest object of the industrial type is the only coal-fired CHP plant in Norway.

Sounds of the Longyear River masking the acoustic impact of many sound sources.

Longyearbyen is constantly growing. The development of Longyearbyen, new activities, new companies will increase in demand for more electricity. This will increase the number of noise sources and higher noise levels in the urban environment. In the long-term, the city's acoustic surroundings will be similar to other European cities. Similar noise measurements and analysis were also made in Barentsburg.

## **1012 Educating the next generation of permafrost scientists and engineers in Svalbard**

**Hanne H. Christiansen\* (1), Graham L. Gilbert (2,1), Arne Instanes (3,4), Arne Aalberg (4)**

(1) Department of Arctic Geology, the University Centre in Svalbard, UNIS, Norway; (2) Norwegian Geotechnical Institute, NGI; (3) Instanes Polar AS; (4) Department of Arctic Technology, the University Centre in Svalbard, UNIS, Norway

Typically university permafrost courses are sparse. However, Svalbard offers a unique opportunity for the next generation of scientists and engineers to learn about permafrost at the bachelor, master, and PhD levels. The University Centre in Svalbard, UNIS, will offer five courses in 2020 to cover different aspects of permafrost science and engineering. At the bachelor level, the full semester

course AT-205 'Frozen Ground Engineering for Arctic Infrastructures' is for students with a background in mathematics, physics, mechanics or engineering, while the AG-218 'International Bachelor Permafrost Summer Field School' is an intensive, early summer 5 weeks rather interdisciplinary study possibility for students with a variety of backgrounds providing an overview of permafrost science and engineering. At master level we offer AT-329 'Cold Region Field Investigations' and AG-330/830 'Permafrost and Periglacial Environments' for students enrolled in relevant master programmes. Finally we will be offering for the first time the interdisciplinary AG-352 'Geohazards and geotechnics in high Arctic permafrost regions' open for master students from both geoscience and geotechnics. Both AG-218 and AG-352 have been developed based on international research collaboration respectively within the University of the Arctic's Thematic Network on Permafrost (TNP), and the INTPART project FROZEN CANOES 'Landscape and infrastructure dynamics in frozen environments undergoing climate change in Canada, Norway and Svalbard'. These courses are taught by an international team of permafrost scientists and engineers. As permafrost is by nature interdisciplinary, we aim to educate students in an interdisciplinary way so that they are able to handle permafrost related processes in different parts of the ecosystem, the cryosphere, in society, in management, and in science and education.

### **1013 Pan-Arctic atmospheric observations during the MOSAiC year**

**Marco Zanatta\* (1), Robin Modini (2), Andreas Herber (1), Roland Neuber (1), Julia Schamale (2), Taneil Uttal (3), Matthew Shupe (3,4), Markus Rex (1) and IASOA station leaders**

(1) Alfred Wegener Institute, Germany; (2) Paul Scherrer Institute, Switzerland; (3) National Oceanic and Atmospheric Administration, USA; (4) Cooperative Institute for Research in the Environmental Sciences, USA.

The Arctic is changing dramatically, with rapid increase of atmospheric surface temperature and decline of sea-ice extent with consequences on feedbacks between the atmosphere, ocean, and sea-ice. The primary objective of the MOSAiC (Multi-Disciplinary drifting Observatory for the study of Arctic Climate) project is to develop a better understanding of these important coupled-system processes so they can be more accurately represented in regional- and global-scale models. With this main goal, the German icebreaker "Polarstern" will drift with the sea ice in the Arctic Sea for a duration of one year between 2019 and 2020. Atmospheric observations will be particularly intensive and cover meteorology, aerosols, trace gases, clouds and radiation. Moreover, the MOSAiC airborne observations will connect three main cardinal points: Polarstern, Ny-Alesund and Villum. However, to really understand the atmospheric climatic processes and atmosphere-surface feedbacks over the entire Arctic scale, interaction and coordination with all Arctic atmospheric stations is mandatory. For this reason, a survey of atmospheric measurements performed during 2019 and 2020 at the IASOA stations in the European Arctic, Russia, Greenland, Canada and Alaska was initiated. Currently, a wide variety of monitoring and special observations from approximately 13 stations has been documented and includes in-situ and remote observations. As an example, aerosol particles properties will be measured at 11 sites during the MOSAiC drift, allowing to investigate the phenomenology of aerosol particles during the MOSAiC year from the European Low Arctic up to 82 degrees north. With the present work we will show the importance of the MOSAiC activity and the necessity of interaction with the IASOA network, in order to finally understand those atmospheric processes still affected by low degree of understanding and improve our ability to estimate the climate change feedbacks.

## **1014 De-icing of Arctic Coasts: Critical or new opportunities for marine biodiversity and Ecosystem Services? ACCES**

**Janne E. Søreide\*, Anna Vader, Amanda Poste, Maeve MCGovern, Jozef Wiktor, Jozef Wiktor Jr., Agnieszka Tatarek, Jazek Urbanski And Jan Marcin Weslawski**

University Centre in Svalbard; Norwegian Institute of Water Research; Institute of Oceanology Polish Academy of Sciences, University of Gdansk

Arctic coastal ecosystems are changing as climate changes and human activities increase, necessitating that government managers, industries, conservation organisations and communities have access to timely biodiversity and ecosystem status data, and if possible to plausible projections of status of biodiversity and ecosystem services over the next decades. The Arctic is characterised by an extensive coastline, constituting 30-40% of the total global coasts. These nearshore waters are among the most productive regions and by far the most preferred ecotype for human settlements in the Arctic. Coastal waters are critical breeding and foraging grounds for many fishes, birds and marine mammals, and provide key ecosystem services that are vulnerable to climate induced stressors. Less sea ice, increased coastal erosion and sediment loads will physically change the nearshore bottom habitats and, thus, the biodiversity of these regions with cascading effects on food webs. Consequently, the coastal ecosystem goods and services (provisional, regulatory, socio-cultural) will also encounter changes. At present the extent of protected coastal marine ecosystems in the Arctic remains very small despite the fact that the Arctic coastal biodiversity is under growing pressure due to climate change and increased human activities.

A strong multidisciplinary team from Norway, Poland, Canada, US and Denmark are now put together to determine biodiversity- and socio-ecological consequences of the change from seasonal ice-covered to ice-free Arctic coasts. We study a wide geographical range of Arctic coastal sites with contrasting ice regimes: Arctic coastlines with extensive seasonal sea ice coverage and Arctic coasts with limited or no seasonal sea ice. For these two scenarios we consider both rocky and soft sediment communities, as well as the unique microorganisms inhabiting the coastal sea ice. Here we present some preliminary results from East and West Svalbard to predict future coastal Arctic climate scenarios.

## **1015 The 51st International Arctic Workshop: June 2021 at The University Centre in Svalbard – UNIS, Longyearbyen**

**Anna J., Pieńkowski\* (1), Mark Furze (2), IAW 51 Local Organising Committee**

(1) Norwegian Polar Institute, Tromsø, Norway; (2) The University Centre in Svalbard, Longyearbyen, Svalbard, Norway

In June 2021, the University Centre in Svalbard and partners in the Svalbard Forskningspark will host to the 51st International Arctic Workshop. This conference and workshop will bring together leading researchers and students in all aspects of high-latitude science, with a particular focus on Svalbard and its place in the circumpolar North. Running since 1970 when the first Arctic Workshop was held at the University of Colorado, Boulder, the workshop is an informal meeting space for scientists and researchers at all career stages working in fields encompassing high-latitude climate, hydrology, glaciology, oceanography, ecology, biology, archaeology, solid Earth processes, social science, engineering, and hazards in past, present and future environments. A strong emphasis is placed on

student involvement, from bachelor to PhD level, the workshop often being the venue at which students present to an international audience for the first time and a major milestone on their educational trajectories.

The workshop is planned for four days in early-mid June 2021. In addition to poster and oral sessions and thematic workshop events, there will be local short afternoon field excursions and an additional multi-day field excursion following the meeting. The Arctic Workshop represents an opportunity for Longyearbyen to showcase its teaching, research, and logistical excellence to an international polar science audience, many of whom may currently have no link to Svalbard but who are interested in developing research and educational connections. Further, it is an ideal opportunity to bring together world leaders and young scientists in Arctic research to explore Svalbard's past, present and future while using the Archipelago as a natural laboratory and exemplar of change across the circumpolar region. All those with an interest in the physical, biological, and human environment of Svalbard and the Arctic are warmly invited to attend.

## **1016 The Acoustics of Ice Caves in the Svalbard for the Design of Modern Acoustic Wall Panels**

**Dorota Czopek\*, Paweł Małecki, Janusz Piechowicz, Jerzy Wiciak**

AGH University of Science and Technology

The paper presents results of an acoustic measurement carried out in ice caves in Svalbard archipelago. During two research expeditions in 2017 and 2018 winter four ice caves were explored: the Longyearbreen Ice Cave, two Larsbreen Ice Cave and the Tellbreen Ice Cave. Caves in glacier are formed as a result of the action of subglacial waters. Such type of caves is carved out of glaciers or snowfields by water and/or wind. The forces of nature will scavenge the ice creating breathtaking shapes and structures. The surface of the walls in the cave can be smooth and hard or create porous structures resembling snow. These various surfaces also have different acoustic properties. Therefore, the acoustics of ice cave could be so interesting for researchers.

In Svalbard's ice caves impulse responses measurements and soundscape recordings were carried out. For these measurements portable measuring equipment were design in such a way to be small and light enough to be carried in backpacks in difficult terrain conditions but at the same time professional. The measuring set includes a portable loudspeaker, ambisonic microphone Soundfield PSP200, handy recorder Zoom H6 and sound level meter Svan 971 with an ACO7052E microphone. For impulse responses measurements sweep sine signal were used. In each cave a series of measurements were made with three or four repetitions at each measuring point. On the basis of recorded impulse responses parameters such as: reverberation time, clarity C50 and definition D50 were determined. Acoustic studies were supplemented with sketches with cave dimensions and photographic documentation. These studies have become a starting point for design of acoustic panels with contemporary and decorative forms.

The project described in this paper has been executed within the project No. 16.16.130.942 in Department of Mechanics and Vibroacoustics of AGH University of Science and Technology in Cracow Poland.

## **1017 Inspirations from the Svalbard's Nature**

**Jerzy Wiciak\*, Bartłomiej Borkowski, Dorota Czopek, Paweł Małecki, Janusz Piechowicz, Anna Szlachta**

AGH University of Science and Technology

Environment acoustics is usually focused on nature protection or to explore and record for posterity a unique soundscape. Most of the results of such studies show the negative impact of phenomena such as global warming on the environment. Some symptoms and courses of that changes are: increase air temperature over ocean and land, rising of global sea level, snow cover reduction and melting glaciers. The article presents a different concept that assumes the use of environmental research as an inspiration to make utility models.

From 2016 to 2018 researchers from AGH University of Science and Technology (Poland) carried out acoustic studies of the natural environment and settlements (inhabited and abandoned) in Spitsbergen. As a part of the research the ambisonic (spatial) recording of acoustic conditions and impulse response measurements in ice caves was carried out. A valuable complement to acoustic studies is extensive photographic documentation and it was the basement to the design of wall acoustic panels. The project was developed through the cooperation of two universities: AGH University and the Jan Matejko Academy of Fine Arts in Cracow.

The paper presents a proposal of acoustic decorative panel. The purpose of the panel is to model acoustic parameters of residential and public spaces. The panel is a combination provide a mix of reflecting and diffusion but also absorption capabilities (if absorbing material is inputted behind it). These properties were achieved thanks to the selection of materials (glass) and spatial structure in terms of mapping the textures found in caves. The article presents a prototype with interesting appearance and its basic acoustic properties. The prototype is the starting point for further acoustic studies and developing the concept of using environmental research to produce utility models with unobvious appearance and acoustic properties.

This research was partly supported by AGH University grant no. 16.16.130.942

## **1018 50 years of observations from the official meteorological station in Ny-Ålesund**

**Mareile Wolff\*, Herdis Motrøen Gjelten, Ketil Isaksen**

Norwegian Meteorological Institute, Oslo, Norway

The meteorological data series from Ny-Ålesund is one of the most frequently downloaded and used datasets from the Norwegian Meteorological Institute's climate data base, illustrating its importance as a unique climate data record for the scientific community.

Ny-Ålesund weather station was established around 1950, and regular observations of all common elements required for an official surface synoptic network station started in 1969. The station is run as a cooperation between the Norwegian Meteorological institute (MET Norway), the Norwegian Polar institute and the Alfred- Wegener Institute, Helmholtz Centre for Polar and Marine research (AWI).

MET Norway is responsible for data transfer, quality control and long-term storage and the data are distributed worldwide by WMO's Global Telecommunication System (GTS) in near real-time. The long term data series is publically available (and easily accessible) due to MET Norway's free and open data policy.

During its long history, the station was moved and upgraded several times. For some periods, parallel measurements exist. For any scientifically sound analysis of the long term data series, especially when assessing climate variability and change in the high-Arctic, metadata describing these changes are indispensable. Until now, these kind of metadata information has not been as readily accessible as the data itself.

Complete metadata, describing the instrument types, the exact siting of the sensors and the applied quality controls, is outlined. It is discussed how these aspects may affect the quality and homogeneity of the time series. In case of parallel measurements, a description of both the official data series and available variations is given. Further, time series for the most common parameters and the development over the last 50 years are presented. Finally, information on how to access the time series and the relevant metadata will be provided

## **1019 The concept of "potential surprise" (G. L. S. Shackle) is a decision-making tool in economics. Can this tool be adapted in Earth sciences to reduce uncertainties between different scenarios?**

**Bernard Lefauconnier\***

Norsk polarintitutt - retired

**Summary note** : The proposed subject will not be presented as a lecture about the Potential Surprise Theory (PST), this subject is far too wide and out of reach for a single (*simple* ?) glaciologist.

The aim is rather to simply draw in a very few minutes, the attention of colleagues working in multidisciplinary departments or institutions to a tool that can provide a new and fresh perspective to better appreciate and choose between scenarios based on plausibility rather than probability and to take decision about it. It should also be noted that the PST can easily focus on extreme events.

## **1020 Study of sea water chemistry changes due to thawing permafrost**

**Maria Pogojeva\* (1,3), Evgeniy Yakushev (2,3), Ilya Petrov (1,3), Evgeniy Yaeski (4), Alexander Polukhin (3), Hans-Frederic Braaten (2), Alisa Ilinskaya (5)**

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Influence of thawing permafrost on the chemical properties of the sea water was studied in 2 experiments organized in Svalbard in 2017 and 2018. Permafrost (PF) samples were collected at an abrasive cliff 10 km west of Longyearbyen. Experiments were focused on identifying the possible changes in concentrations of nutrients, carbonate system parameters, and pollutant composition related to permafrost thawing. During the experiment, the samples of permafrost were added to the seawater. The solution was exposed to natural conditions for 24 hours in 2017 and 5 days in 2018

while water samples from the solution were taken at specified time intervals. The results of the experiment show that the sea water composition changes are connected to the permafrost thawing. Data from this experiment allowed us to estimate the total annual supply of nutrients to the Arctic from permafrost thawing by multiplying the change in concentration from this study by the annual eroded permafrost total volume in Siberia.

## **1022 Post-industrial development of Russian mining towns at Svalbard: a community study**

**Andrian Vlachov\* (1)**

(1) National Research University Higher School of Economics

Svalbard, the Arctic archipelago of Norway, has been an important ground for international Arctic research for many decades, mainly due to its geographical position, natural diversity and unique legal status. However, most academic publications concerning Svalbard belong to natural sciences, while the human dimension of the archipelago remains poorly known. That is especially true for the social sciences: the structure of the local communities and the relevant social practices were rarely studied by scholars, and the Russian settlements were nearly always overlooked due to cultural and language barrier.

My research project aims to bridge that gap by systematically describing the Russian communities in Svalbard. I have been using participant observation, in-depth interviews, social networks monitoring and media analysis to trace and capture the process of post-industrial transition taking place in Barentsburg and Pyramiden during the last few years.

In this paper, I present the provisional outcomes of my research project. I argue that Barentsburg is a unique type of Arctic industrial settlement as compared to company towns and shift villages. I also analyze the structure of the local community, its take on the town development, and the strategies of industrial and non-industrial futures used by actors at different levels.

Another objective of this paper is to explore the role of legacies of resource extraction in de-industrializing mining communities at Svalbard. Since the 2000s, mining companies have scaled down their operations significantly and coal mining plays a diminishing role in the future visions of business and state actors on the archipelago. I analyze this process of change through the lens of the Russian mining towns at Svalbard. My study investigates how different actors have re-shaped the town, by focusing on narratives about the past, present and future of Barentsburg and Pyramiden and the views of the various stakeholders on new activities.

## **1023 Useful Arctic Knowledge (UAK): Partnership for research and education between Norway, USA and Canada**

**Stein Sandven\*, Hanne Sagen, Torill Hamre, Lisbeth Iversen, Espen Storheim**

Nansen Environmental and Remote Sensing Center

The main goal of the UAK project, funded under the INTPART programme, is to build and maintain partnerships between educational and research institutions in Norway, USA and Canada on selected



Arctic topics. These topics, which are relevant for research in Svalbard, include: (1) Studies of natural and human-made hazards with focus on earthquakes, slope failures and fuel-spills, including the causes behind the hazards, how they can be monitored and how risks can be minimized and impact mitigated. (2) Status and change of the ocean acoustic environment, which is affected by increased shipping, tourism and exploitation of resources in the Arctic regions. The impacts of acoustic noise on the environment is important for developing mitigation plans for protection of marine life. (3) Cross-disciplinary data management and building knowledge from the increasing amount of data in the Arctic, especially from satellites, is important. (4) Community based monitoring evolves as an important contribution to an integrated Arctic Observing System. UAK is capitalizing on the experience in USA and Canada on Community based monitoring, where this method has been developed over many years. UAK brings together leading researchers and educators in natural science topics, community-based monitoring and data management. A research school was organized at UNIS in December 2018 with 30 participants from eight countries. Further training and education activities will contribute to build cross-disciplinary competence and use of modern data collection and dissemination methods. It is also expected that the educational programs developed with support from UAK will have positive impact on cooperation among the science, business and public sectors through our collaboration with local communities and stakeholders in the study areas.

## **1024 Multi-instrument approach for the correction of observed precipitation in the Arctic**

**Hans-Werner Jacobi\* (1), Kerstin Ebell (2), Sybille Schoger (2), Mareile A. Wolff (3)**

(1) Institute for Geosciences and Environmental Research (IGE), University Grenoble Alpes / CNRS / Grenoble INP / IRD, France; (2) Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany; (3) Norwegian Meteorological Institute, Oslo, Norway

Liquid and solid precipitation are important climatic variables in the Arctic that are expected to have undergone significant changes in the past and will undergo further changes due to the changing climate. However, it is well known that standard gauges to measure precipitation can strongly be biased especially in the case of solid precipitation. Here, we will present results of different gauges in different settings at Ny-Ålesund covering a full hydrological year from 2017 to 2018 with different temporal resolution ranging from minutes to days. Standard correction methods considering meteorological parameters like temperature and wind speed are applied to correct all observations. Based on the generated corrected time series, we will analyze the impact of the time resolution of the instruments on the calculated corrections. We will discuss the impact of the corrections and their uncertainties on the annual accumulation and the derived solid and liquid precipitation distribution.

## **1025 Can tephra enhance Svalbard chronology and improve links between sedimentary archives?**

**Wesley R. Farnsworth\* (1,2), Esther R. Guðmundsdóttir (2, 3), Ólafur Ingólfsson (2), Maarit H. Kalliokoski (2), Kurt H. Kjær (4), Mike Retelle (1,5), Anders Schomacker (3)**

(1) University Centre in Svalbard; (2) University of Iceland; (3) The Arctic University of Norway, UiT; (4) University of Copenhagen; (5) Bates College

Yes. However, no stratigraphic framework for tephra has been developed for the High Arctic. We present preliminary results of distally deposited (crypto-) tephra found within Svalbard Holocene lake sediments as well as pumice re-deposited on post-glacial raised marine shorelines. Results suggest there is great potential in extending a stratigraphic framework of distally deposited tephra into the High Arctic based on Holocene archives in Svalbard. Not only do new results from Svalbard place the distal deposition of tephra on a pan-Arctic scale, but findings bridge gaps relating to the direct comparison of sedimentary archives.

## **1026 Learning from Earth's History: The Unprecedented Need Now for International Collaboration**

**Julie Brigham-Grette\* (1)**

(1) University of Massachusetts-Amherst, US NAS Polar Research Board

CO<sub>2</sub> in our atmosphere is increasing faster than any time in human history. Paleoclimate records show that we have to look beyond 800,000 years to find a time when CO<sub>2</sub> concentrations were even briefly as high as today (415 parts per million, or ppm), and back 3 million years during the Pliocene Epoch to when CO<sub>2</sub> was consistently that high. Based on past changes in the Earth system, scientists predict that unless we can offset this rise, the concentration of atmospheric CO<sub>2</sub> will return our planet to Pliocene conditions/ with rising seas, shifted weather patterns and altered conditions in both the natural world and human societies. If we are heading into Pliocene-like conditions, what was the world like at ~415 ppm? Unlike today, boreal forests reached the Arctic Ocean across much of Arctic Russia and North America. The Greenland Ice sheet did not exist, only small glaciers existed along eastern Greenland. In Antarctica, the West Antarctic Ice sheet was absent, replaced only by an open seaway. Given the infrastructure of cities and businesses at the coast today, we must mitigate warming via non-polluting technologies, while developing resilient federal and state policies for managing resilient coastlines, water supplies, fisheries, and agricultural practices.

Collaboration and science diplomacy across international boundaries is key to forging the partnerships necessary to slowing climate change. It is more important than ever that we press forward as a united International community using Arctic Council Agreements on Arctic Access to forage science collaboration for the good of Society.

## **2001 Ice Edge Retreating: Influence on Maritime Activities around Svalbard**

**Alexandra Stocker\* (1), Angelika Renner (1), Maaïke Knol (2)**

(1) Institute of Marine Research, Tromsø, Norway; (2) UiT – The Arctic University of Norway, Tromsø, Norway

Climate change is leading to rapid sea ice loss in the Arctic, which gives rise to increased maritime activity. This presentation will visualize the retreating ice edge combined with the increase of

fisheries and passenger vessels around Svalbard over the past six years (2012-2018) through a series of maps, and will reflect upon the wider implications of these results. For the maps, two datasets were used. The sea ice concentration was obtained from passive microwave satellite data retrieved from AMSR-2. The information about vessel mobility was derived from automatic information system (AIS) data provided by the Norwegian Coastal Administration, showing the position of vessels sailing in the waters in Svalbard's exclusive economic zone. These datasets were merged, and the analysis reveals a clear increase in maritime activity over the past six years, both in terms of number of vessels operating around Svalbard, and in terms of the lengthening of operational seasons. Based on a series of additional qualitative interviews with sea ice researchers, decision makers, and representatives of fisheries and cruise tourism organisations, we will reflect upon the implications of these developments, which gives new insights of how sea ice variability is considered in terms of safety implications, the need for adapted governance as well as improvement of sea ice services for this region.

## **2002 Melttown: Longyearbyen as a community in the midst of environmental, economic and societal change**

**Zdenka Sokolickova\* (1,2)**

(1) Department of Study in Culture and Religion, University of Hradec Kralove, Czech Republic ; (2) Department of Social Anthropology, University of Oslo, Norway

Svalbard might be at the edge of the world geographically but is at center stage in terms of accelerating changes in environment, economy and society. Processes accompanying climate change and globalization are highly articulated in Longyearbyen in unique ways that may soon be experienced elsewhere. The natural environment is becoming more dangerous and unpredictable, the economy more turbulent, and the society less Norwegian. People living in Longyearbyen are concerned — on different levels and for different reasons — about all these trends. The two-year-long anthropological fieldwork of Zdenka Sokolickova in Longyearbyen (started in February 2019), under the supervision of Thomas Hylland Eriksen from the University of Oslo as a mentor, is inspired by Eriksen's concept of overheating in a world that is "too full and too fast; uneven and unequal," and its implications for local communities. The poster presents core hypotheses and research questions of the project and discusses preliminary outcomes.

## **2003 Setting priority to Climate change and Cultural Heritage at Svalbard: For how long will the historic remains still be visible?**

**Anne-Cathrine Flyen\* (1)**

(1) Norwegian institute for Cultural Heritage Research

Geological hazards, fungal decay and trampling tourists are threatening Svalbard's historic remains at an ever accelerating pace. Last Chance Tourism has become a popular and well-known phenomenon and is actively used in marketing Arctic destinations.

This paper gives an overview over the international cultural heritage stock of Svalbard and discusses what is happening with the historic remains at the archipelago in a changing climate, based on research and fieldwork during the last 15 years. The aim of the paper is to highlight Svalbard's cultural heritage as part of Arctic research, to show how the climate affects the degradation and the

condition of cultural heritage sites in the area, and to propose a way forward in the management of these international cultural heritage sites.

The research shows that coastal erosion is threatening cultural environments and landslide is causing great stresses to standing buildings and ruins. Most of the more than 2000 single heritage structures of Svalbard are wooden and heavily decayed by fungus. However, it is not only natural degradation that breaks down Svalbard's cultural monuments. Degradation from human use is a growing problem. The monuments are often indifferent and small, and difficult to perceive as worthy of preservation. Mostly wooden and heavily degraded they easily collapse when trampled on. This makes them vulnerable to visits and leads to accelerated degradation.

Key questions to be discussed in the paper are:

- Why is the cultural heritage and cultural heritage research in Svalbard important?
- What is actually happening with the international cultural heritage of Svalbard?
- For how long will the cultural remains still be visible?
- What will be the best strategies in cultural heritage management in years to come?

## **2004 Signatures of winter and spring warm events in the snowpack from Hans glacier, Hornsund area**

**Krystyna Koziol\* (1), Aleksander Uszczyk (2), Filip Pawlak (1), Klaudia Kosek (1), Daniel Kępski (3), Adam Nawrot (3), Żaneta Polkowska (1), The C2s3 Project Consortium (4)**

(1) Gdansk University of Technology; (2) University of Silesia; (3) Institute of Geophysics, Polish Academy of Sciences; (4) Community Coordinated Snow Survey in Svalbard project team

The Arctic has been warming at twice the average global rate, with implications for its snow cover structure and chemical composition. In ice cores, ionic ratios have been recommended as a chemical signature of melt occurrence and intensity (Vega et al., 2016). However, the usefulness of ionic ratios to unravel short-term (< 1 year), incomplete snow chemistry records has not been established, while they should also be linked to the preferential elution process (e.g. Brimblecombe et al., 1987; Cragin et al., 1996).

In this work, three years of ionic snow composition upon Hans glacier, Wedel-Jarlsberg Land, are investigated (2016-2018). The contributing datasets include an excerpt from a Svalbard-wide snowpit campaign (spring 2016, C2S3 project) and snow cores collected in a spatial pattern upon the surface of Hans glacier (2017 and 2018). Ionic ratios indicative of melt events are investigated in the known horizontal ice and melt-refreeze crust layers of the thoroughly described snowpits. Then, we test a similar procedure to the subsamples of snow cores obtained in the following two years. We interpret the data in the context of the winter snowfall and temperature history at the nearby Hornsund station and on Hans glacier itself. The conclusion concerns whether ionic ratios are an appropriate tool for investigating melt patterns in single-year snow accumulation records with sparse meteorological information or in incomplete snow layer chemistry datasets.

### **Acknowledgement:**

SSF (project no. 257636/E10) funded the C2S3 field campaign (2016). Institute of Geophysics, PAS, and its Expeditions no. 38, 39. and 40. to Hornsund supported the laboratory and field work (as did

University of Silesia in 2016). This work was also supported by Pedagogical University in Cracow internal funds and the Polish National Science Centre (NCN) grant no. 2017/26/D/ST10/00630.

## **2005 Sea ice loss increases isolation of reindeer populations across Svalbard**

**Bart Peeters\* (1), Mathilde Le Moullec (1), Joost A. M. Raeymaekers (2,1), Jonatan F. Marquez (1), Knut H. Røed (3), Åshild Ø. Pedersen (3), Vebjørn Veiberg (4,1), Leif Egil Loe (5), Brage B. Hansen (1)**

(1) Centre for Biodiversity Dynamics, Norwegian University of Science and Technology, Trondheim, Norway; (2) Faculty of Biosciences and Aquaculture, Nord University, Bodø, Norway; (3) Department of Basic Sciences and Aquatic Medicine, Norwegian University of Life Sciences, Oslo, Norway; (4) Norwegian Polar Institute, Tromsø, Norway; (5) Norwegian Institute for Nature Research, Trondheim, Norway; (6) Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway

Sea ice loss is expected to have dramatic consequences for the persistence of wildlife species across polar ecosystems. In this study, we show how metapopulation genetics in the endemic, high-arctic Svalbard reindeer (*Rangifer tarandus platyrhynchus*) are shaped by the interactive effects of sea ice cover and extinction-colonization dynamics linked to past overexploitation. Svalbard reindeer have the lowest genetic diversity of all *Rangifer* subspecies. However, we found very high genetic differentiation among populations. Landscape genetics revealed significant isolation by distance (Mantel's  $r = 0.48$ ) among populations, but much stronger isolation by resistance ( $r = 0.70$ ) explained by barrier effects of glaciers and open water, and strong connectivity across sea ice. Hence, Svalbard reindeer are dependent on sea ice to avoid inbreeding and increase the probability of recolonizing areas after local extinction events. Interestingly, the highest levels of genetic differentiation were found between the reintroduced populations near Ny-Ålesund (Brøggerhalvøya, Sarsøyra, Kaffiøyra and Prins Karls Forland) and the naturally recolonized population at Mitrahalvøya, about 20 km north of Kvadehuken, Brøggerhalvøya. This clearly indicated a lack of interbreeding since their local extinction from overharvesting and recent recolonization in the late 20<sup>th</sup> Century, and was very likely linked to the overall lack of sea ice along the west and northwest coast in recent decades. On a pan-Arctic scale, continued loss of sea ice as a dispersal corridor is expected to increase the genetic isolation of populations, and even subspecies, and thus threaten the evolutionary potential and persistence of Arctic wildlife.

## **2006 Impact of the tidewater glacier retreat on bottom-up ecosystem processes in Kongsfjorden, Svalbard**

**Pedro Duarte\* (1), Philipp Assmy (1), Laura Halbach (3), Anette Wold (1), Hanna Kauko (1), Lasse Olsen (4), Mikko Vihtakari (2), Haakon Hop (1), Tomas Torsvik (1), Jack Kohler (1), Arild Sundfjord (1), Harald Steen (1)**

(1) Norwegian Polar Institute, Tromsø; (2) Institute of Marine Research, Tromsø; (3) Department of Environmental Science, Aarhus University, Denmark; (4) Department of Biological Sciences, University of Bergen

Glaciers around the world are retreating as a result of global warming and tidewater glaciers (TWG), whose fronts terminate in the seawater, are experiencing the most rapid changes. Recent literature emphasizes the ecological importance of TWG fronts where the high abundances of zooplankton and fish turns them into important foraging grounds for seabirds and marine mammals. Tidewater glacier fronts are also sites of intense upwelling during the melting season due to rising freshwater plumes

from subglacial discharge. These plumes may entrain nutrient-rich water and stimulate primary production, providing a source of “new” nutrients during the summer, when nutrients are rapidly depleted by phytoplankton. Consequently, the landward TWG retreat raises the question how the marine ecosystem will be affected when subglacial discharges are replaced by surface glacier discharges. Recent studies suggest negative effects on coastal primary and secondary production, especially in the case of TWG with a grounding depth of several hundred meters, where the rising plumes bring deep nutrient-rich waters to the surface. We used empirical and modeling data to answer the above question for Kongsfjorden, where the grounding depth for TWG is <200 m in an interdisciplinary project involving glaciologists, oceanographers, biologists and modelers. Our results suggest important differences between the present and the future scenarios associated with the landward TWG retreat, resulting in a decrease in nutrient availability and phytoplankton abundance, with negative consequences for higher trophic levels. Such patterns are apparent despite the relatively shallow grounding depth of Kongsfjorden TWG. Our understanding of these phenomena would benefit from a better knowledge about the chemical and biological characteristics of the subglacial discharges that may not be sampled with traditional techniques, instead requiring usage of remotely and/or autonomously operated vehicles. Upscaling our results to the entire Svalbard archipelago is an important next step with adequate sampling and modeling tools.

## **2007 High-resolution geophysical imaging of the permafrost – Initial result of two high arctic expeditions to Spitsbergen**

**Mariusz Majdański\* (1), Artur Marciniak (1), Bartosz Owoc (1), Tomasz Wawrzyniak (1), Adam Nawrot(1), Michał Glazer (2), Marzena Osuch (1), Wojciech Dobiński (2)**

(1) Institute of Geophysics, Polish Academy of Sciences, Warszawa, Poland; (2) Department of Earth Sciences, University of Silesia, Sosnowiec, Poland

Presented research focuses on recognition of the “shape” of the permafrost, and show seasonal changes which affect the cryospheric components of the Hornsund area, Spitsbergen. The two data-sets, from autumn 2017, and spring 2018, were gathered during two expeditions, to directly compare the state of active layer and permafrost in different seasons. The seismic profiles were carefully designed, to show a variety of geological structures. One was shot to image changes in permafrost between the seashore and the mountains, the other one to image the ice-cored glacial sediments of retreating Hans glacier. During the data processing steps, authors were able to estimate the main physical properties of the research area, that was important in further imaging with reflection seismic. The special effort was made to estimate the uncertainty of the results, making them comparable and reliable. The analysis of high-resolution seismic profiles, performed during different seasons in Spitsbergen proved to be an efficient way to estimate the seasonal changes in active layer thickness. It was also possible to clearly verify the sediments - bedrock boundary. Additionally, the ground thermal regime from the new boreholes established in 2017 with depths reaching 20 m has been recognized. New data provide a more detailed and updated ground thermal profiles than any previously available from Southern Spitsbergen. Before the active layer characteristics and thickness remained unknown. The main result is an observation of a sharp change of reflectivity that is horizontal and continuous at the whole range of observation. This area is interpreted as the bottom of the permafrost, that was recognized from 100 m near the coast down to 600 m close to mountains. Obtained unique geophysical information about Hornsund geocryology and its changes, may be

useful for a wide spectrum of specialists interested in the dynamics of the climate and cryospheric changes.

## **2008 A shape of Hansbreen in Southern Spitsbergen during the Holocene Climate Optimum**

**Jacek A. Jania\* (1), Grzegorz Rachlewicz (2), Małgorzata Blaszczyk (1), Mariusz Grabiec (1)**

(1) Centre for Polar Studies, University of Silesia, Sosnowiec, Poland; (2) Adam Mickiewicz University, Poznan, Poland

Warmer climate during the Holocene Climate Optimum (HCO) was identified by different methods in many regions. Studies on the HCO climatic and environmental conditions in Svalbard are still sparse. In this study data for Hansbreen (a tidewater glacier in southern Svalbard) are presented. A length of whale's rib bone was melted out from the lateral part of the glacier front. It has striations marks proving subglacial transport. A fossil peat melted out from the glacier was found on its lower reach along the longitudinal shear zone between the tributary Fuglebreen and the main glacier tongue. They were dated by the  $C^{14}$  method, giving uncalibrated dates  $7160 \pm 240$  BP (Gd-9998) and  $5200 \pm 240$  BP (Gd-13000). Another peat portions were found recently on the surface of the tributary glacier Tuvbreen significantly higher than the previous ones. To reconstruct extent of the glacier during the HCO, ice thickness and the glacier bedrock topography were mapped by ground penetrating radar and a pattern of flow directions of the glacier has been defined by remote sensing methods. Both sets of data permitted to indicate approximate locations of collected organic samples before removing them by glacier erosion. The rib bone and the already dated peat samples might be associated to the surface of the raised marine terrace (c. 10 m a.s.l.) extended along the western side of the Hansbreen valley which is currently under ice. Other peat samples come to the ice surface from the bottom of the Tuvbreen valley. Knowing the glacier's bedrock topography which lies well below sea level underneath of the main stream and considering locations of sources of the organic samples, it is very likely that, during the HCO, the main trunk of Hansbreen did not exist at all and only the highest cirques in tributary valleys might be occupied by small glaciers.

## **2009 Performance of Arctic seaweeds in a changing environment: what does 'polar' mean?**

**JL Gordillo\* (1), Concepción Iñiguez (1)**

(1) University of Malaga, Spain

Hardbottom polar coastal areas are densely populated by macroalgae, many of which are present even during the long winter period. A number of campaigns have been carried out in cooperation with the AWI (Germany) in Kongsfjorden (Svalbard), and common macroalgae species have been tested for their ability to perform in an increased atmospheric  $CO_2$  and/or increased temperature scenario. We have shown that increased  $CO_2$  can modify the carbon balance of different species in different ways, affecting both their ability to cope with summer excess light and their internal composition, in a manner different to their cold-temperate ecotypes (North Atlantic). The relationship between the operation of a carbon concentrating mechanism (CCM) and Rubisco kinetics was studied in seventeen populations of macroalgae from Arctic, Antarctic and cold-temperate ecosystems comprising the three phyla. When possible, latitudinal comparisons were

made for the same species/genus. Rubisco carboxylation kinetics (the semi-saturation constant for CO<sub>2</sub>, K<sub>c</sub>, and the catalytic constant, K<sub>cat</sub>) was analyzed at 4 °C and 25 °C. In the red *Palmaria sp.*, the carboxylase catalytic efficiency (K<sub>cat</sub>/K<sub>c</sub>) was the highest in the endemic Antarctic *P. decipiens*, followed by the Arctic *P. palmata*, while the lowest was *P. palmata* from the North-Atlantic, more notably at 4 °C. In the kelp *Saccharina latissima*, K<sub>cat</sub>/K<sub>c</sub> was also higher in the Arctic than in the North-Atlantic population at both temperatures assayed. The green *Acrosiphonia arcta* did not show a different rubisco kinetic but a significant increase in rubisco content in the polar (Arctic and Antarctic) than in the North-Atlantic population. Despite a relatively high affinity and low K<sub>cat</sub>, most algae showed an active CCM according to their δ<sup>13</sup>C and pH compensation point values. These results will be discussed in terms of evolutionary adaptation to cold environments and the potential risk of ocean acidification and warming.

## **2010 Glaciers as secondary sources of inorganic pollutants**

**Agata Zaborska\* (1)**

(1) Institute of Oceanology Polish Academy of Sciences

As the consequence of the global warming, glaciers that accumulated different contaminants for decades have started to melt. Thus the recent and historical loads of contaminants of eg. heavy metals and radionuclides to the Arctic coastal areas should be monitored. This case study was conducted in Hornsund (Svalbard) which host several very actively melting glaciers. Ten 40cm long sediment cores were collected in different distance from glaciers. In total over 200 sediment samples were analysed. Levels of selected heavy metals and <sup>137</sup>Cs were measured by ICP-MS and gamma spectrometry respectively. Sediment dating allowed to retrieve contaminant deposition history. Study have shown that although heavy metal concentrations and <sup>137</sup>Cs activity concentrations in Svalbard fjord sediments are not particularly elevated yet, their loads are about 10 times higher at the glacier fronts as compared to central fjord parts. Contaminant loads are much larger than their recent atmospheric deposition suggesting that secondary sources of those elements to the fjord sediments are much more important than direct source (atmosphere).

## **2011 Is the Svalbard tundra getting wetter? – Evidence of vegetation change and it's drivers over the last 20 years**

**Helen Anderson\*, Audun Stien, Leif Egil Loe, René Van Der Wal**

University of Aberdeen; NINA; NMBU; SLU

To assess changes in tundra plant communities since 1998, and the drivers thereof, we undertook a re-visitation study of 100 plots (2 x 2 m) and 34 transects (x-y km) located across Nordenskiöld Land. Changes across 9 different plant communities, ranging through the wetness spectrum from dry polar desert to very wet marshes, were analysed. Generally, a shift towards wetter communities was observed, with evidence of changes in plant functional groups and cover within those communities. Polar horsetail *Equisetum arvense* has increased significantly in all wetter communities, whilst in the *Dupontia/Eriophorum* marshes *Dupontia spp.* cover has significantly reduced. We found goose grubbing to be widespread across the tundra. This was generally of low extent (< 5% of a plot), except in *Dupontia/Eriophorum* marshes, where over three-quarters of the plots that had been



disturbed by geese were extensively grubbed (up to half of the plot). Evidence of reindeer grazing and trampling was less widespread than goose grubbing. The extent of disturbance by reindeer was low and the areas where it was most evident were the more mesic and wetter plant communities. Environmental disturbance (landslips, slumps, frost boils, polygon structures and cracks in the ground) occurred in a quarter of all plots, leaving noticeable disturbance to the tundra with large areas of bare soil. Over the last 20 years, the Svalbard tundra mean annual soil temperature at several depths has risen by approximately 4°C and annual and seasonal air temperatures have also increased. Pink-footed goose numbers have risen and recently stabilised. We propose that the changes observed in tundra plant communities are due to a complex interplay between an increase in depth of the active layer, changing hydrology patterns, rising temperatures and higher numbers of pink-footed geese, who preferentially feed in wet *Dupontia/Eriophorum* marshes when possible, making predictions of future change difficult.

## **2012 Use of glacier fronts by foraging black-legged kittiwakes**

**Philip Bertrand\* (1,2), Sébastien Descamps (1), Joël Bêty (2), Hallvard Strøm (1)**

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Arctic temperatures are known to increase at a fast pace. The increase in temperatures also promotes melting of tidewater glaciers, bringing a significant amount of freshwater discharge into the sea (*i.e.*, calving front). Glacier discharges promote the rise of upwelling plumes, carrying plankton to the surface. Due to the increased accessibility of preys, these calving fronts appear as important feeding zones for marine vertebrates such as the black-legged kittiwake (*Rissa tridactyla*; hereafter kittiwake). Although spatially limited, glacier fronts have been highlighted for their potential to mitigate, at least in the short terms, the effect of climate-induced sea-ice loss on Arctic ice-associated community. This component remains however largely hypothetical due to data limitations, scarcity and the complicated logistics involved in their study. Preliminary results from the Kongsfjorden system suggest however that the magnitude of use of glacier fronts by the birds varies temporally and spatially. We found that the kittiwakes were highly repeatable in the level of use of these sites, associated to a greater reproductive success in birds using the glacier fronts. We found however that the level of difference in reproductive performances between glacier front user and non-user varies interannually, suggesting that the benefits of using these sites as foraging area are also conditional to the underlying fjord environmental conditions (211 words).

## **2013 From sea to summit: behavioural responses to increasingly severe winter feeding conditions in high-Arctic Svalbard reindeer**

**Larissa T. Beumer (1), Brage B. Hansen (2), Åshild Ø. Pedersen\* (3)**

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Snow-pack properties, such as snow depth, snow hardness and basal (ground) ice, are significant barriers limiting northern ungulates' access to forage during winter. In the Arctic, winters are warming rapidly, with associated changes in precipitation regimes and snow-pack properties. For island ungulates, such as the wild Svalbard reindeer, current changes in tundra winter feeding conditions occur in parallel with rapid loss of sea-ice, an important dispersal and migration corridor. In this review, we discuss the variety of behavioral and dietary responses to severe winter feeding conditions, in particular icing events associated with rain-on-snow (ROS), as demonstrated through a combination of long-term population monitoring, observational studies, fecal analyses, and GPS-collar data of Svalbard reindeer. In this endemic sub-species inhabiting a predator-free environment and characterized by a more or less solitary behavior, individual reindeer may respond to ice-locked tundra through small-scale seasonal migrations between semi-isolated valleys or peninsulas, with an apparent positive net fitness effect compared to resident individuals. In coastal populations, reindeer also expand their realized foraging niche to include washed-ashore kelp and seaweed as a dietary substitute when feeding conditions are markedly restricted on the tundra. Furthermore, deep snow or icing triggers many individuals, particularly adult males, to seek steep mountainous areas for easier access to forage. Reindeer remaining in their 'normal' winter feeding habitat at low altitudes demonstrate a remarkable ability to locate small, ice-free micro-patches by smelling food plants through the snow-pack. This wide variety of behavioral and dietary strategies indicates a substantial level of plasticity and adaptive landscape use, which can – at least in part – buffer negative fitness implications of the current and future anticipated increase in icy winters.

## **2014 Sustainable drinking water supply in Longyearbyen and climate change: present challenges and future opportunities**

**Anatoly Sinitsyn\*, Hanne Kvitsand**

SINTEF Community

In Svalbard and other Arctic societies, there is an ongoing concern regarding access to adequate quantities of drinking water of acceptable quality. Permafrost forces Arctic communities to rely on climatically controlled surface water sources for drinking water supply. These raw water sources often freeze during wintertime, resulting in no or limited available water for drinking water production. For example, in Longyearbyen, the water supply is dependent upon river during summer, with the dammed lake "Isdammen" as an emergency the water source. Particularly vulnerable conditions take place during fall and winter when the river freeze, and water supply is completely dependent on the Isdammen. This is a vulnerable situation for the Arctic society of Longyearbyen, including residents, visitors, business/industry, power supply and heating plants.

Climate observations and projections predict warmer and wetter climate in Svalbard in the 21<sup>st</sup> century. It is expected that these climate changes will increase the thickness of the active soil layer and warm the permafrost, and that the hydrological regime of rivers and lakes will change. This may open opportunities for introduction of new technologies for extraction of drinking water in Svalbard in the 21<sup>st</sup> century. It can be transfer of well-developed or introduction of cutting-edge technologies, which are primarily developed for conditions of cold regions in temperate climate.

Observations from other polar regions indicate that groundwater may exist in withdrawable amounts in Svalbard in hydraulic connection to surface water sources. In light of the changing climate, the

possibilities for groundwater extraction may increase. Further investigations of hydrological conditions and assessment of climate change impacts on them are required for revealing of opportunities for sustainable drinking water supply in Longyearbyen.

## **2015 Cultural Heritage Sites in Coastal Areas. Use, Monitor, Manage and Preserve Sites & Landscapes under Climate Change and Development Pressure (CULTCOAST)**

**Vibeke Vandrup Martens\* (1), Anne-Cathrine Flyen (1), Cecilie Flyen (2), Knut Stalsberg (3), Lena Rubensdotter (3), Hans Renssen (4), Tom Dawson (5), Ionut Cristi Nicu (1)**

(1) NIKU, Norwegian Institute for Cultural Heritage Research; (2) SINTEF; (3) NGU; (4) USN; (5) St Andrews University, Scotland

Cultural heritage and cultural environments are highly valued environmental goods, but these values are under serious threat from multiple sources. Climate is changing now at an even higher rate than expected in some of the worst-case climate scenarios, with increasing temperatures, changes in precipitation, decreasing permafrost, more frequent and severe storms, sea level rise, reduction of sea ice, floods, avalanches and changing vegetation (Climate Research Unit, 2018). These changes increase the risks of geo-hazards, e.g. erosion caused by wind, waves and rivers that threaten particularly coastal heritage sites, environments and landscapes. The northern areas are particularly sensitive because they suffer more from combined threats and have previously been well protected by the aid of permafrost and sea ice. As impacts and effects of climate change are global and the bequest value of heritage, preserving it for future generations, is of relevance everywhere, our studies will be transferable to CH management plans and mitigation actions at national and global scales, to meet the UN Sustainable Development Goals on resilient and sustainable settlements and taking urgent action to combat climate change and its impacts.

The CULTCOAST project focuses on the individual and combined impacts of climate change induced geo-hazards and pressure from tourism and development in northern Norway, using Arctic and sub-Arctic sites as basis for future modelling that will have global use. Based on existing methodologies for mapping and documentation, strategies for adaptation, mitigation and conservation will be developed to protect these sites in the decades towards the year 2100.

## **2016 Ecological plasticity – a key skill to survive in a changing Arctic, tested on *Calanus***

**Emilia Trudnowska\* (1), Kaja Bałazy (1), Joanna Ston-Egiert (1), Thomas Brown (2), Irina Smolina (3), Marta Gluchowska (1)**

(1) Institute of Oceanology Polish Academy of Sciences, Poland; (2) Scottish Association for Marine Science (SAMS), Scotland; (3) Nord University, Norway

If we are to understand the actual and to predict the future functionality of north polar marine ecosystems, we definitely need to recognize the susceptibility of the key ecosystem components to the climate oscillations. Copepods of the genus *Calanus* are the basis of the Svalbard food webs, supporting large stocks of fish, birds, and mammals. Although particular *Calanus* species are morphologically very similar, they have different life cycle strategies, centres of distribution and roles

in the ecosystems. Therefore so far they have been highly valued also as good biological indicators of the hydrographical-ecological regimes and consequently of the effects of the ongoing climatic changes. However, due to problems with proper *Calanus* species identification, the knowledge about their ecological plasticity and functioning in various oceanic conditions is still very limited.

The aim of this study is to verify the actual differences between *C. finmarchicus* and *C. glacialis* with regard to their ecological plasticity. Our hypothesis is that the studied species' traits (e.g. size, pigmentation, population demography, lipid content, diet) will differ depending on the fact if particular species inhabit the preferable water mass or exist in suboptimal conditions (due to temperature, competition). Therefore the study was performed both in the waters from each particular species originate from (the Atlantic domain for *C. finmarchicus* and the Arctic domain in the case of *C. glacialis*) as well as in the waters in which they coexist (inside Hornsund fjord).

The proper identification of species was related to their ecological traits. We observed a difference in size, pigmentation and diet in particular species between suboptimal and optimal conditions. It is the first study that simultaneously incorporated so many aspects to improve our taxonomical and ecological species recognition and their plasticity, which is the first step for predicting future ecosystem shifts in northern hemisphere.

## **2017 Ecological resilience of Arctic marine food webs to climate change**

**Gary Griffith\*, Haakon Hop, Mikko Vihtakari, Anette Wold, Kjersti Kalhagen**

Norwegian Polar Institute

The implications of changes in species interactions of complex real world food webs to absorb, recover and adapt (i.e. ecological resilience) to climate change effects remains problematic. Here, we apply a new approach to identify changes in resilience of a highly observed Arctic marine food web (2004-2016), considered a harbinger of future Arctic change. We show how the response of the system to changing environmental conditions can be understood through a set of self-organising configurations representing different simultaneously nested and multiple species interactions. We find that while resilience declined to year 2011, core ecological processes have been maintained. We identify a recent emergent pattern of improving ecological resilience explained by continuing subsidiary inputs of Atlantic species repairing (self-organizing) interactions within some configurations. Our findings demonstrate that Arctic marine food webs can absorb, recover and begin to adapt to on-going climate change effects.

## **2019 Contrasting consequences of climate change for migratory geese**

**Kate Layton-Matthews\*, Brage Bremset Hansen, Vidar Grøtan, Eva Fuglei, Maarten J.J.E. Loonen**

Norwegian University of Science & Technology; Norwegian Polar Institute; University of Groningen

Climate change is most rapid in the Arctic, posing both benefits and challenges for migratory herbivores. However, population-dynamic responses to climate change are generally difficult to predict, due to concurrent changes in other trophic levels. Migratory species are also exposed to contrasting climate trends and density regimes over the annual cycle. Thus, determining how climate change impacts their population dynamics requires an understanding of how weather directly or indirectly (through trophic interactions and carryover effects) affects reproduction and survival

across migratory stages, while accounting for density dependence. Here, we analyse the overall implications of climate change for a local non-hunted population of high-arctic Svalbard barnacle geese, *Branta leucopsis*, using 28 years of individual-based data. By identifying the main drivers of reproductive stages (egg production, hatching and fledging) and age-specific survival rates, we quantify their impact on population growth. Recent climate change in Svalbard enhanced egg production and hatching success through positive effects of advanced spring onset (snow-melt) and warmer summers (i.e. earlier vegetation green-up), respectively. Contrastingly, there was a strong temporal decline in fledging probability due to increased local abundance of the Arctic fox, the main predator. While weather during the non-breeding season influenced geese through a positive effect of temperature (UK wintering grounds) on adult survival and a positive carryover effect of rainfall (spring stopover site in Norway) on egg production, these drivers showed no temporal trends. However, density-dependent effects occurred throughout the annual cycle and the steadily increasing total flyway population size caused negative trends in overwinter survival and carryover effects on egg production. The combined consequences of these density-dependent processes and direct and indirect climate change effects across life history stages appeared to stabilise local population size.

## **2020 Coastal change in a warming Arctic**

**Maria Jensen\* (1), Lena Rubensdotter (1,2), Agnes Baltzer (3), Kyungsik Choi (4), Franck Garestier (5)**

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The coastline of Svalbard is highly dynamic. Coastal erosion, delta progradation, longshore drift and spit migration are parts of the Svalbard coastal environment and contribute to bathymetry changes, risk for infrastructure and cultural heritage, sediment budgets and nutrient fluxes to fjord ecosystems. Hydrological change, permafrost degradation and increased slope instability change rates and sources of sediment supply from land to the coast. Changes in sea ice cover and wave activity affects the distribution of sediment from land to the sea.

Until recently no quantification for change existed for the vast majority of the Svalbard coastline. Since 2017 baseline data for the coastal configuration in Isfjorden has been collected, which can now be combined with studies of coastal change on an annual to decadal time scale at representative sites in the Svalbard fjords. The aim of the studies are to quantify coastal change, understand the sediment delivery routes to the coast in different settings and understand the effect of open water for a significant part of the year/all year. This allows us to better predict coastal change both close to settlements and in remote parts of the archipelago, which is relevant for environmental and cultural heritage management. It also provides data on coastal sediment storage and release with implications for nutrient fluxes for marine ecosystem studies as well as for earth system models. We present the ongoing coastal mapping project of Isfjorden (DynaCoast) and the follow up remote sensing project MovingCoasts using SAR images to track high resolution coastal change. We also present close-up examples from the ongoing monitoring of coastal change in Kongsfjorden, Dicksonfjorden, Adventfjorden and Braganzavågen, and discuss how different settings are expected to respond differently to a warming climate scenario.

## **2021 An ice-covered sub-Arctic fjord – Glimpse into the future of Svalbard fjords?**

**Ulrike Dietrich\*, Tobias Vonnahme, Emma Persson, Eva Hejdukova, Christine Dybwad, Josef Elster, Rolf Gradinger**

UiT – The Arctic University of Norway, Tromsø, Norway; Charles University, Prague, Czech Republic; University of South Bohemia, Ceske Budejovice, Czech Republic

Freshwater discharge into the ocean from melting glaciers and permafrost is predicted to increase significantly due to rising temperatures in Svalbard. The freshwater input adds nutrients, but also increases the turbidity and stratification in fjord systems, affecting the biomass and composition of microalgae.

As the freshwater is less dense, it stays on top of the water column. It increases the chance of sea ice formation during winter but could in turn act as a physical barrier for microalgae to reach the ice. Furthermore, freshwater ice lacks the feature of brine channels, thus making it inhabitable for microalgae. We hypothesize that a seasonally ice-covered sub-Arctic fjord can be used as a model site to predict future scenarios in Svalbard fjords.

We will test our hypotheses by studying the stratification, microalgal community structure and biomass, gel particles, and nutrient concentrations along a transect from the inner to the central part of the fjord.

Sea ice and water in Ramfjorden (Troms, Norway) was sampled from January to April 2019. Ramfjorden is characterized by a freshwater layer beneath the ice (salinity of 1.5 to 2.8), and low brine salinity and percent volume, ranging from 0.0 to 23.9, and 0.0 to 5.0 in the lower three cm of ice, respectively. In addition, no skeletal layer was observed.

A comparison with the high-Arctic fjord Billefjorden (Svalbard), shows great similarity in sea ice physics and water column stratification right in front of the tidewater outlet glacier Nordenskiöldbreen. In contrast, sea ice in the center of Billefjorden formed a skeletal layer with visible microalgal biomass (under-ice water salinity 36.4), and brine salinity and percent volume of 41.3 and 16.2, respectively.

With increasing freshwater discharge to Svalbard fjords, sea ice associated microalgal biomass could be significantly reduced, leading to a food-limited habitat for higher trophic levels in early spring.

## **2022 Warmer winters in Kongsfjorden will compromise the survival of interannual seaweeds**

**Carlos Jiménez\*, Raquel Carmona, Manuel Macías & Francisco JI Gordillo**

University of Málaga, Spain

Four species of representative macrophytes from Kongsfjorden hard bottoms (the Ochrophytes *Saccharina latissima* and *Alaria esculenta*, and the Rhodophytes *Phycodrys rubens* and *Ptilota gunneri*) were incubated in the dark for a period of 16 weeks, simulating Arctic winter, at two different temperatures (3.5 and 8°C). Fresh weight, respiration, net photosynthesis, carbohydrate, lipid and protein content were followed. Results indicate that red macrophytes coped with darkness

better than the brown ones, as well as with increasing temperature, and nearly no differences in composition and capacity for O<sub>2</sub> production occurred during the extended dark cultivation in the former ones, while in kelps a significant loss of biomass was observed accompanied by a drop in photosynthetic O<sub>2</sub> production when re-exposed to light after the dark period. In addition, red macrophytes lost just a small proportion of their biomass during darkness. The fate of the thalli as well as respiration and net photosynthesis were affected by temperature, mainly in kelps, and, in general, respiration and thalli degradation was higher at 8°C. Interestingly, *A. esculenta* produced new blades during the last four weeks of the dark incubation, anticipating the availability of light. Additionally, the capacity for electron transport was maintained in all thalli, indicating that the light harvesting system was kept fully operational even after 16 weeks in the dark. These results indicate that Arctic macrophytes must be genetically adapted to cope with prolonged dark periods, surviving during the polar winter, and that increasing temperature during winter may significantly affect survival of some kelps.

## **2023 Assessing the role of sea ice as a dispersal vector of plants in a changing climate**

**Maria Dance\* (1,3), Marc Macias-Fauria (1), Erin Saupe (2)**

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Multiple lines of evidence indicate that sea ice has enabled the long-distance dispersal (LDD) of Arctic-Alpine plants to remote Arctic archipelagos such as Svalbard since the last glacial period. Today, ice-rafted material reaches Svalbard predominantly via the Transpolar Drift, which transports material from the Siberian coast. However, recent evidence suggests that less sea ice formed in the Siberian coastal shelves reaches the Fram Strait, despite faster sea ice drift, due to the decline in sea ice age. The ongoing reduction in sea ice may therefore impact plant dispersal to Svalbard and the wider Arctic. However, a baseline assessment of the role of sea ice in contemporary Arctic plant LDD does not exist.

We present a research plan which aims to a) quantify the importance of sea ice as a vector for plant LDD under climate change, and b) compare contemporary patterns with the historical role of sea ice in post-glacial dispersal. Svalbard is an isolated High Arctic archipelago at the receiving end of the Transpolar Drift which makes it an ideal study system for sea ice-mediated plant dispersal.

Fieldwork beginning in spring 2020 will sample beaches and coastal ice on the west and east coasts of Spitsbergen, and the north coasts of Spitsbergen and Nordaustlandet, in order to compare ice-free areas, first-year ice, and multi-year ice, respectively.

The taxonomic and genetic diversity of ice-rafted plant material will be compared with established Svalbard and circumarctic assemblages to determine a) possible source regions and b) if new plant material brings novel species and/or genetic diversity. We hypothesise that first-year ice transports plant material within Svalbard, but multi-year ice harbours material from elsewhere. Any plant propagules found on ice will be tested for viability. With the Arctic Ocean predicted to be seasonally ice-free within decades, the timeframe to conduct this assessment is limited.

## **2024 Human land use and CO<sub>2</sub> exchange in the high Arctic: Svalbard case**

**Dmitry Karelin\* (1,2), Elya Zazovskaya (1), Vasily Shishkov (1), Nikolay Osokin (1)**

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Summarized the results of long-term observations (2014-2018) of soil emissions and net CO<sub>2</sub> fluxes (2017-2018) in natural and human-modified (HM) ecosystems of Arctic tundra in archipelago of Svalbard (78°04N, 14°13E). Factors associated with local land use, during the period of their active impact may redouble the emissions of carbon dioxide from soil ( $0.111 \pm 0.021 > 0.064 \pm 0.011 \text{ gC m}^{-2} \text{ h}^{-1}$ ). During warm period the net C-balance at the sites with active land use was estimated as a source to the atmosphere. Self-recovering after human influence plots (2) demonstrate intermediate values of soil emissions of CO<sub>2</sub> between unaffected tundra (1) and plots with active land use (3). With that they demonstrate the greatest net C-sink within the observed range of Photosynthetically Active Radiation as compared to (1) and (3). At the height of the vegetation period unaffected tundra demonstrate a neutral net C-balance. The greatest contribution to soil emissions variance make spatial factors (56-66% of variance), whereas temporal controls are responsible for 3.8-5.5% only. Inter-annual fluctuations of key controls, among which the most important are the soil moisture and temperature of the upper layer, both affect HM and natural ecosystems. Hence the spatial differences between them remained constant from year to year. We conclude that HM arctic ecosystems during periods of active land use with high probability become an additional net carbon sources to the atmosphere. But if the human pressure is halted, under recovery they convert into a sinks of C, which compensate for the first effect. The rate and degree of the compensation depends on particular type of human footprint. This often leads to overcompensation and positive atmospheric effects, but native plant communities are not restored, which is associated with permafrost degradation. The study was supported by RFBR grant 18-05-60279-Arctica, and state assignments AAAA-A18-118052400130-7 and 0148-2017-0005 of Russia.

Keywords: CO<sub>2</sub> soil emission and net exchange, Arctic tundra, Svalbard, land use

## **2025 Is the past the key to the future? Holocene warming in the Arctic, present and future**

**Jan Marcin Węśławski\* (1)**

(1) Institute of Oceanology Polish Academy of Sciences

Traditionally, geologists and paleontologists have little in common with marine physics or biologists or social sciences. Yet, such cooperation is in great need in the attempt to understand the mechanisms and possible scenarios for the ongoing ecosystem change on Svalbard. History offered us an example – the Last Holocene Warming (approx 9-7 thousands years b.p.) was well documented in the Arctic, and Svalbard in particular by the absence of most tidal glaciers, elevated air and sea temperatures and abundant occurrence of thermophilic bivalve *Mytilus edulis* on the coast. Furthermore, baleen whales were very abundant and plankton feeding birds not, contrary to the present situation. Both terrestrial and marine biota were very different from today. The existing data on this past event belongs to the domain of Earth Science and were not really discussed by contemporary ecosystem scientists and environmentalists, who publish in different journals and attend different conferences. The urgent problem to solve is the question if the past warming was just a “regime shift” – advance of North Atlantic – boreal system North, bringing quantitative not qualitative changes or was it the „tipping point” phenomenon irreversible and can’t be repeated, bringing qualitative changes. Social science and management will have a strong support from the



analyses of past warming and its environmental consequences. Quoting Niels Bohr “it’s difficult to make predictions, especially for the future” – much more rewarding is to learn from the past.

## **2026 The Arctic climate transformation and the effects on the cryosphere**

**Ketil Isaksen\*, Inger Hanssen-Bauer**

Norwegian Meteorological Institute, Oslo, Norway

A new Arctic is emerging due to climate change. Over the past 50 years, the temperature in the Arctic has risen twice as fast as the global average. The increase of air temperature by 3 to 5 °C in Svalbard makes this region one of the fastest-warming areas in the world, with widespread consequences. Recent winters have been characterised by periods of extraordinarily warm weather in combination with intense rainfall, causing ecological disturbance and new challenges for societies and infrastructure. The permafrost in Svalbard has the highest ground temperatures this far North in the Arctic and has warmed considerably. In addition, Longyearbyen and its surroundings are experiencing a number of natural hazards.

This presentation will explore the effects of global warming on the frozen components of the Arctic, the so-called cryosphere. The emphasis is on the terrestrial environment, especially related to changes in permafrost and snow cover. The consequences of these ongoing and predicted changes for nature as well as society will be outlined, with examples across the Arctic including Svalbard.

The presentation is partly based on two recent assessments; The Snow, Water, Ice and Permafrost in the Arctic (SWIPA) by the Arctic Monitoring and Assessment Program and Climate in Svalbard 2100 by the The Norwegian Centre for Climate Services. Both assessments highlight the need for new monitoring efforts coordinated across disciplines, to give access to reliable and up-to-date information. Tough decisions on climate change adaptation will have to be made in Svalbard and the Arctic in the coming years and it is essential that they are based on multi-disciplinary science.

## **3001 – 3009 Social Science and Beyond in Svalbard – Poster Exhibition**

**Samantha Saville (1), Dina Brode-Roger (2), Eva la Cour (3), Patrizia Isabelle Duda (4), Laura Ferguson (5), Alexandra Meyer (6), Lisbeth Iversen (7), Eva Kotaskova (8)**

(1) Department of Geography and Earth Science, Aberystwyth University; (2) KU Leuven; (3) Valand Art Academy, the Faculty of Fine, Applied and Performing Arts, University of Gothenburg; (4) University College London; (5) Queen's University Belfast; (6) University of Vienna & Project Nunataryuk; (7) NERSC Bergen/ INTAROS-project; (8) Masaryk University

Alongside the well-established natural and physical science activities, there is also a long tradition of artistic, literary and historical engagements with Svalbard and a perhaps lesser-known body of social science research. Scholars of international relations, sustainable development, environmental management, tourism, cultural and industrial heritage, anthropology, and geography have all contributed to an understanding of Svalbard as not only a site of unique geology, glaciology, biology and astro-physics, but also as a place that has been visited, inhabited and discussed over centuries. Historians and social scientists have investigated past and present changes in human activities here for decades.

Now, as Svalbard, and Longyearbyen in particular, is undergoing rapid societal and environmental changes (that are inextricably linked to one another), there is an increased attention and need to

examine the possibilities and relationships between complex factors that shape the future of life in Svalbard. An understanding of the past as well as analysing the present is vital here. Of course, just as the environmental research that is undertaken in Svalbard contributes to global data sets and understandings, there are also potential lessons the rest of the world can learn from in terms of how a small community adapts to rapid socio-economic, cultural and environmental changes.

This series of posters will present the work of active members of the newly formed Svalbard Social Science Initiative (SSSI). The aim of this group is to better co-ordinate social science research in Svalbard and to make it more visible, more useful and more responsive to the local community. The exhibition will incorporate a brief summary of the value of social science in this context and introduce the SSSI. The main body of the exhibition will feature project summaries and findings from nine early career researchers working in social science and humanities fields in Svalbard, as summarised below.

#### **Tentative list of posters:**

Dina Brode-Roger, KU Leuven, *Identity in Change: Mapping the Impact of Climate Change on the Community of Longyearbyen*

Eva la Cour, Valand Art Academy, the Faculty of Fine, Applied and Performing Arts, University of Gothenburg. *The Figure of the Guide: Mediating the Arctic Terrain.*

Patrizia Isabelle Duda: University College London. *Informal Disaster Governance on Svalbard.*

Dr. Laura Ferguson, Queen's University Belfast. *Longyearbyen's Coal Mining Heritage: For Town and For Tourism.*

Alexandra Meyer, University of Vienna & Project Nunataryuk, *The Societal Impacts of and Adaptation to a Changing Environment in Longyearbyen, Svalbard: An Ethnography of Arctic Change*

Lisbeth Iversen, NERSC Bergen/ INTAROS-project, PhD-Candidate-The Oslo School of Architecture and Design. *Knowledge based planning, development and monitoring in the Arctic. Linking top-down with bottom-up approaches and Community Based Monitoring programmes.*

Eva Kotaskova. Masaryk University. *Enacting Environment in Svalbard Tourism Industry.*

Dr. Samantha Saville, Department of Geography and Earth Science, Aberystwyth University. *Svalbard Futures: Value and Adaptation in the Anthropocene.*

## **4001 Dark season observation of methane dynamics in seepages across Svalbard: clear signals and less noise**

**Andy Hodson\* (1), Aga Nowak (1), Peter Betlem (1), Hanne H. Christiansen (1), Kim Senger (1), Alexandra V. Turchyn (2), Kelly R. Redeker (3), Søren Jessen (4), Mikkel T. Hornum (4)**

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The potency of methane (CH<sub>4</sub>) as a greenhouse gas means that changes in its emission to the atmosphere as a result of thawing Arctic permafrost deserve urgent attention. In Svalbard, these emissions are rather poorly understood, in spite of a great effort being directed at understanding the release of methane from the sea floor. Here we therefore describe terrestrial methane seepages in Svalbard and demonstrate how observations during winter greatly facilitate their detection, on-site

investigation and sampling. We will show that despite the harsh Arctic conditions, vital insight (signals) into the methane dynamics of groundwater seepages may be discerned in winter, because surface meltwaters (noise) do not dilute the source waters and render sampling logistically impossible. We will also show that these perennial methane seepages exploit pingos and geological fault systems, to produce supersaturated springs. On many occasions, those springs have concentrations of both thermogenic and biogenic methane at levels several orders of magnitude greater than equilibrium. The highest values observed marginally exceed the solubility limit for methane in water at 0 °C (i.e. 41 mg.L<sup>-1</sup>). Furthermore, seasonal maximum dissolved CH<sub>4</sub> concentrations are usually observed in winter, when hydro and/or thermal fracturing of the frozen sediment and ice covering the seepages allows rapid ventilation to the atmosphere. Differences between the δ<sup>13</sup>C-CH<sub>4</sub> composition of the winter samples and the late summer samples suggest only minor methane oxidation prior to these fracture events. However, the extent of oxidation in summer can be highly variable, depending upon the site location and discharge characteristics of the seepage. In Adventdalen, emissions from four pingo springs constitute ca. 25% of the annual methane flux from the entire valley. Small hotspots of methane emission from groundwater seepages therefore deserve careful monitoring for a better understanding of methane emissions and winter field work is essential for this task.

## **4002 Micro- and macroalgae during the Polar night**

**Geir Johnsen, Eva Leu\*, Rolf Gradinger**

NTNU/ UNIS, Akvaplan-niva, UiT – The Arctic University of Norway

The extended period of darkness during the Polar night represents a major challenge for marine primary producers in Svalbard and uni- and multicellular algae have evolved different strategies as adaptations. Unicellular microalgae cope e.g. by formation of resting stages, mixotrophy, and downregulation of metabolic activity. On the other hand, some macroalgae take advantage of the special conditions during wintertime and even use them for growing actively based on stored metabolic energy. Both groups seem to be able to resume photosynthesis very rapidly once they are re-illuminated. We here give an overview of what we know about algae in the Polar night in terms of diversity and life cycle and physiological adaptations – and also what is still unknown. Due to its accessibility year-round, Svalbard is an excellent study area for Polar night ecology, and we summarize findings from numerous studies that have been carried out during the past decade.

## **4003 Terrain and circulating factors of distribution of monthly and annual averages of Land Surface Temperatures (LST) in the Svalbard area**

**Alfred Stach\* (1), Grzegorz Rachlewicz (2,1)**

(1) Institute of Geocology and Geoinformation, Adam Mickiewicz University, Poznań, Poland; (2) Department of Environmental Science, Xi'an Jiaotong-Liverpool University, China

The LST reflects the combined effect of surface and weather conditions that together regulate energy flows between the atmosphere and the ground. In the polar regions, LST is one of the most important factors affecting the location and character of permafrost, glacial mass balance and ecosystem dynamics. Satellite thermal sensors enable synchronous area evaluation of regional and

global LSTs. This is particularly valuable for the vast and hard-to-reach Arctic landscapes where the locations where direct LST measurements are performed are very rare and their spatial representativeness is severely limited.

In this analysis, LST timely data from MODIS sensor operating on Terra and Aqua satellites (4 measurements per day) from 2000-2019 were aggregated to monthly periods. It covers the whole Svalbard archipelago area. The aim of the study was to identify and quantify the significance of terrain and atmospheric circulation factors influencing the seasonal variability of LST in the archipelago.

Spatial variation LST is, in seasonal terms, determined mainly by factors related to location (static): coordinates, land cover and its relief as well as distance from water. Their relative importance changes throughout the year. Boosted Tree Regression predictive models, considering these factors, gave errors ranging from 0.41 to 0.83°C. These models are globally unbiased, while spatial autocorrelation of errors was found, possibly due to the influence of atmospheric circulation (dynamic) factors. The combination of cluster analysis and principal component analysis enabled the separation of 10 types of monthly LST distributions in the Svalbard archipelago. They are characterized by a seasonally variable probability of occurrence, and the analysis of the frequency of occurrence of certain types of atmospheric circulation during periods of their duration showed very statistically significant differences. The influence of circulating factors on the formation of the average monthly LST on Svalbard can be estimated at 20%.

#### **4004 Spectral analysis of the light pollution in Ny Ålesund**

**Jean Liliensten\*, Léo Bosse**

IPAG-CNRS-UGA

Ny Alesund is the northernmost scientific village in the world. It could be easily used as a unique base for astronomical and auroral observations. Already several auroral instruments are at use. However, the internal light pollution prevents from making absolute optical measurements. In this poster, we will show the spectral analysis of the light pollution in Ny Alesund and how this interfere with the main auroral emissions. We will show that the situation is still worth in Longyearbyen, and that the Polish polar base Hornsund could be considered as the example to follow if one wants to develop auroral and astronomical observations.

This work is part of the efforts developed in WG 8 of the Atmospheric Flagship program: “Middle and Upper atmosphere”.

#### **4005 Triangulation of auroral structures by observations at Svalbard**

**Boris Kozelov\*, Alexei Roldugin, Sergei Pilgaev, Valery Grigoriev**

Polar Geophysical Institute, Murmansk-Apatity, Russia

The precipitations of energetic electrons observed at Svalbard, which manifest themselves in the optical range as auroras, differ in their origin and morphology from the precipitations in other regions of the auroral zone. The electron energy determines the height of the auroral luminescence, which in the experiment can be determined from triangulation observations.

From 2018, optical devices of the Polar Geophysical Institute on the Spitsbergen archipelago were supplemented with an additional camera. The camera is installed in the Barentsburg settlement, 4 km south of the main optical pavilion and has a field of view of about 35 degrees. In patrol mode, the camera is directed to the zenith, which allows, together with the data of the all-sky camera, located in the main optical pavilion, to obtain information about the height of the observed structures of auroras in the vicinity of the zenith. The report contains the parameters of the optical system used for triangulation and examples of the registration of auroral structures.

## **4006 QUARCCS in the dark: results from the two site German-Russian surface energy flux comparison campaign**

**Alexander Schulz\***

Alfred Wegener Institute Potsdam

One year ago AWI in cooperation with AARI conducted a two site surface energy flux comparison campaign with two flux towers on Svalbard: 1 tower at the Kongsfjorden (Ny-Ålesund); 1 tower at the Isfjorden (Barentsburg, Heerodden). This campaign (Sep. 2017 – Sep. 2018) was a work package of the bilateral German-Russian project QUARCCS ending by the end of this year (2019). Two key questions within this work package were:

1. What are the differences (and the similarities) of the Earth's energy balance at the surface between both sites?
2. How do clouds influence the turbulent exchange at the surface?

Let's take a look into the results of the most recent data analysis with a strong focus on the Svalbard's dark season.

## **4007 Zooplankton in Svalbard waters during the Polar Night**

**Malin Daase\*, Jørgen Berge, Laura Hobbs, Stig Falk-Petersen, Gerald Darnis, Janne Søreide**

UiT The Arctic University of Norway; The University Centre in Svalbard; Scottish Association of Marine Science; Akvaplan-Niva; Quebec Ocean, Department Biologie, Université Laval, Quebec

Pelagic communities play a key role in Arctic marine ecosystems. Although zooplankton occupy several different levels in the food chain, their main functionality is often considered to be the key linkage between pelagic and ice associated primary producers and higher trophic levels. Zooplankton ecology is thus often viewed and understood in relation to primary production regimes. While the polar summer is characterized by high zooplankton activity to accomplish reproduction, growth, development and energy storage within a short time window of high sympagic and pelagic primary production, the polar night has traditionally been characterized as a period with low biological activity, with herbivorous species receding into diapause at greater depth while omnivorous and carnivorous species are just inactively waiting until biological activity resumes, stimulated by the return of light and food in spring. Given the remoteness of polar regions, zooplankton studies from the polar night are rare. However, over the last decade marine research in Svalbard has shifted the focus towards seasonal studies, including the polar night, providing new insights into numerous new aspects of zooplankton ecology. Recent studies have showed that winter processes may be key for

understanding zooplankton life strategies and potential to adapt to new climatic conditions. As a group, they are active throughout the entire year, they conduct various forms of vertical migrations in relation to both the moon and solar background illumination, and some species utilize the polar night for reproduction. Here we will summarize recent findings and identify knowledge gaps that need to be addressed in future polar night studies to improve our limited understanding of ecosystem processes outside the productive season.

## **4008 Columnar aerosol properties in the Arctic: emphasis in nocturnal photometry**

**D Mateos\* (1), C Toledano (1), R Román (1), C Velasco-Merino (1), R González (1), J C Antuña (1), C Guirado (1), C Ritter (1)2, V E Cachorro (1), A Calle (1), A M De Frutos (1)**

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The determination of atmospheric components in Polar regions is essential for improving our knowledge on climate change and its impact on such areas. Aerosol studies in the Arctic point out the marked seasonality as well as the intrusion of long-range transported polluted air masses as major characteristics. Taking advantage of the development of the new technique of solar-sky-moon photometry, columnar observations can be carried out using both Sun and Moon as light source (reflected light in the case of the Moon). The Atmospheric Optics Group of University of Valladolid and German Alfred Wegener Institute for Polar and Marine Research installed in 2017 a solar-sky-moon CIMEL-318T photometer, in the framework of AERosol ROBotic NETwork, in the Arctic Base of Ny-Ålesund (79°N). This instrument is recording a continuous database of columnar aerosol properties and also precipitable water vapor.

This study presents the preliminary results of spectral aerosol optical depth and water vapor during winter periods. High quality summer data are also included in the analysis. Some case studies of long range transport are also analyzed in detail by means of the retrieval of complex inversion products. AIRS remote sensing products are also presented in this study to obtain the seasonal behavior of water vapor and cloud cover for comparison with ground-based observations. Some synergies of collocated instruments in the site are going to be exploited. Instruments such as LIDARs, photometers, ceilometers, sky cameras, in-situ data, among others, should be integrated in novel algorithms like GRASP to obtain the most reliable data with respect aerosol properties and their vertical distribution. Finally, planned activities in Ny-Ålesund base are also described. The main activity in winter'2020 will be an inter-comparison field campaign in the base about lunar photometry involving different international institutions and instruments.

## **4010 Synergistic Investigation of Arctic Aerosol in the darkness: remote sensing and in-situ perspectives**

**Konstantina Nakoudi\* (1,2), Christoph Ritter (1), Mauro Mazzola (3), David Cappelletti (4), Christine Böckmann (5), Marion Maturilli (1), Roland Neuber (1)**

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In January 2019 coordinated atmospheric measurements took place in Ny Ålesund. The goal of the campaign was to improve our knowledge on aerosol properties during Polar night. To this end, a combined measurement perspective of remote sensing and in-situ was adopted. The laser beam of the “Koldewey Aerosol Raman Lidar” (KARL) emitting radiation at 1064, 532 and 355 nm, was giving information on aerosol backscatter, extinction and depolarization. Concurrently, in-situ sensors installed on the tethered balloon “Flying Mozzarella” measured aerosol’s optical and physical properties, as well as captured particles on filters. The numerical inversion of Lidar observations will provide evidence on aerosol concentration, size and shape, to be compared with in-situ balloon data. In parallel, filter analysis is going to reveal the chemical composition and size distribution of the aerosols, exploiting Scanning Electron Microscopy (SEM) analysis. The aim of this study is to link the aerosol optical impact with the aerosol chemical composition, as derived from different measurement techniques. With combined aerosol measurements being scarce during Polar night, the closure between remote sensing and in-situ measurements constitutes a significant step in advancing the understanding on the role of aerosol in the Arctic climate system. Particularly, a regular calibration of Lidar data by in-situ data will increase our knowledge on the vertical distribution of aerosol. This information is needed to constrain the aerosol radiative forcing and it will be useful in comparing the Ny-Ålesund findings to measurements and modelling efforts from other Arctic sites.

## **4012 Exploring the dark in the spirit of Nansen**

**Marit Reigstad\***

University of Tromsø – The Arctic University of Norway and PI *Nansen Legacy* project

Our image of the Arctic marine polar night, as a period where all organisms and processes exist in a stand-by mode waiting for the light Arctic spring, has been proven wrong during the past years. Recent investigations from Svalbard has shown a world where darkness is a relative term, and where many marine organisms are active, and the polar night is a time for critical ecological processes. This glimpse of light into the polar night calls for increased attention and investigations during the winter period. To understand on-going changes in the climate- and ecosystem, we need to understand 1) the annual cycles of environmental conditions and organisms’ lives, 2) processes within and couplings between atmosphere, sea ice, ocean and ecosystem, and 3) how these systems, processes and organisms respond to changes.

The lack of baseline knowledge on the Arctic marine systems, specifically during the winter and polar night, combined with on-going rapid changes in climate, makes the future a dark secret. To provide scenarios of a future marine Arctic, we need a more interdisciplinary and holistic approach than traditional research projects allow. The *Nansen Legacy* project answers this need.

In the spirit of Fridtjof Nansen, who set out to understand the Arctic Ocean and how it connects to lower latitudes, the *Nansen Legacy* contributes extensive new knowledge to scope out, integrate and connect the Barents Sea and adjacent Arctic Ocean to the entire Arctic. By providing new data, observational systems, improved models and future scenarios on the emerging Arctic, a future sustainable management is possible. The *Nansen Legacy* exemplifies how innovative research and science organisation can address knowledge gaps and foster a new generation of polar researchers – trained across disciplines, institutions and nations – providing the competence we need to handle the new Arctic future.

## **4013 International Collaboration in order to address Grand Challenge**

### **Questions in Earth System Science**

**Jøran Moen\***

University of Oslo, Norway; University Centre in Svalbard, Norway

The Arctic faces dramatic changes due to warmer climate, but also new opportunities for economic exploitation. The ice melt down opens for new sea routes, and natural resources now under the ice cap will be a subject to economic exploitation. An increase in sea traffic, complex maritime operations, search and rescue operations, is foreseen. Risk management in this scenario requires reliable models for climate prediction, weather forecast, ice maps, and space weather.

The Grand Challenge Initiative – Cusp project, GCI-Cusp, a collaboration between NASA, JAXA, SIOS and the University of Oslo (UiO) to coordinate an observing system consisting of twelve sounding rockets, ground observatories, and satellites. The GCI-Cusp project was initiated to strengthen the potential to close grand science questions about Solar Terrestrial coupling. One societal challenge related to it, is the need for space weather models to predict the reliability of GPS navigation and positioning. The Northern Light is associated with disturbances on radio waves for both communication and navigation, but we still lacking a physics model for it.

We are now mobilizing international effort for a much bigger project, the, Grand Challenge Initiative - Mesosphere and Lower Thermosphere (GCI-M/LT). In the stratosphere and mesosphere, between 10-90 km altitude, the residual meridional circulation is driven by dissipating gravity waves. Gravity wave forcing is included in global circulation models (GCM) merely as a factor, but is not properly modeled. This introduces uncertainties in climate scenario predictions. The GCI-M/LT project will investigate sub-grids scale processes in the mesosphere-lower thermosphere in order to develop more realistic models for global circulation.

In the GCI-observing system development, we adapt to the SIOS data management system for storing and making data openly accessible and reusable for new research projects developed within and outside the GCI-consortium, and hence to maximize the return on the investments.



## **5101 Svalbard Rock Vault 2020: let us safeguard Svalbard's geoscientific heritage together**

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Svalbard's history is closely linked with the exploitation of its natural resources. Geology, in particular the presence of coal-bearing strata, defines where most of Svalbard's settlements are found. Coal exploration has resulted in hundreds of boreholes and tens of kilometers of cores, whereas eighteen deep boreholes have been drilled for petroleum exploration between 1961 and 1994. Recently, research drilling targeting subsurface CO<sub>2</sub> storage generated unique core material through much of the Mesozoic succession.

How are borehole data from Svalbard organized? Where are the cores, the samples, the well reports, the geophysical data sets and other geoscientific data? Unfortunately some of the material is lost forever, being thrown away or left at the mercy of elements in the Svalbard outdoors. Some physical material is found in numerous data repositories in Svalbard, in Norway or abroad. Reports from petroleum exploration are still held by the operating companies, but many of these companies are either bankrupt or merged with other companies.

Through the Svalbard Rock Vault (SRV) initiative we strive to lay the foundation for establishing a safe geoscientific data archive, especially important in today's turbulent times associated with a rapid decrease in coal mining activity. The SRV comprises both a physical storage facility in Longyearbyen and a Geodata portal to facilitate finding and accessing the data for research and education purposes. For instance, we have fortunately recovered the archive material from Norsk Polar Navigasjon, a company involved in drilling half of the petroleum boreholes, and are archiving and digitizing the reports for easy access.

In this contribution we present an update of the SRV pilot project (2019-2020) that endeavors to define a concrete plan on the organizational model and long-term financing. Furthermore, SRV is interested in input from geoscientists working in Svalbard through a questionnaire to be launched at the Svalbard Science Conference.

## **5102 Autonomous monitoring station of hydrology in Adventelva river**

**Uta Brandt\*, Pernilla Carlsson, Amanda Poste, Øyvind Kaste, Elisabeth Lie**

Norsk institutt for vannforskning (NIVA)

NIVA has established sensor-based monitoring stations for research on land-ocean interactions at three different sites in Norway, in the temperate (southern Norway), subarctic (Troms region) and in the Arctic climate zones. The station installed in Svalbard is located in the Adventelva river, close to the town of Longyearbyen and is therefore easily accessible for maintenance and additional sampling. A buoy in Adventfjorden near the river outlet (measuring temperature, salinity, turbidity,

FDOM (fluorescent dissolved organic matter) and chlorophyll fluorescence) was also installed in April 2019 to complete the monitoring set-up for research related to land-ocean interactions.

This presentation focuses on the technical aspects of the river monitoring infrastructure such as choice of materials, sensors and data communication, as well as the potential for new research possibilities connected to the monitoring stations.

The monitoring station allows for continuous *in situ* sensor-based measurement of several parameters in the river, including water level, temperature, conductivity, pH, and turbidity. Sensors are deployed seasonally from June to September/October and the data are sent to NIVA's central database once a day. The station is designed to be flexible, with the possibility for deployment of additional sensors in order to address specific research needs or to complement planned field campaigns.

Data from the Adventelva station is already used in several research projects such as TerrACE (NFR), and FreshFate (Framsenter) where data from the monitoring station provide valuable add-on environmental data. In particular these sensor-based data allow us to characterize physicochemical conditions in the river with high temporal resolution, and, when paired with field and sensor-based measurements in the marine system, give important insight into the effects of riverine inputs on coastal biogeochemistry and ecology.

### **5103 Sensing drifters for glacial hydrology measurements**

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Subglacial hydrology studies are required for a better understanding of glacier dynamics. However, limited access impairs comprehensive surveys of the subglacial environment. Lagrangian drifters present a novel way to measure flow features along glacier channels and might therefore present an answer to the subglacial measurement challenge. We present a new rugged drifter platform, which measures total water pressure, magnetic field strength, linear acceleration and drifter rate of rotation while flowing along a glacial stream. The drifters have been tested on Svalbard glaciers for two consecutive summers. In this presentation, we present and critically assess the repeatability of glacier surface velocity data. Furthermore, we show how data from the drifter platform might be linked to glacial channel flow features.

### **5104 Near-Remote Sensing of Svalbard's Vegetation**

**Elisabeth Cooper\*, Lennart Nilsen**

UiT The Arctic University of Norway

It is important to monitor the vegetation on Svalbard and to be able to relate any observed changes to changes in environmental conditions as well as herbivore impacts. Since large areas of the Arctic are inaccessible, there has been a great increase in the use of satellite-based remote sensing tools as

well as drones carrying remote sensing equipment for this task. However, the interpretation of the remotely-sensed images has to be done with caution, and ground truthing is necessary for correctly understanding the electronic information obtained. We have established a set of near-remote sensing vegetation stations in a range of common vegetation types in Adventdalen and Ny Ålesund, and can use these to compare values measured at ground level and by eye, with those taken by a range of sensors. We will present and discuss the use of this type of equipment for bridging the gap between human and remotely sensed monitoring of vegetation.

## **5105 Estimation of the average monthly air temperature distribution on Svalbard based on satellite data and terrain characteristics**

**Alfred Stach\* (1), Grzegorz Rachlewicz (2,1)**

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Svalbard Archipelago is an international research training ground of High Arctic natural environment state and changes tendencies, encompassing cryosphere, landforms, Earth surface processes and ecosystems. The knowledge of climate conditions in various spatial and temporal scales is a base of such investigations. However, the dimensions and diversification of the archipelago is causing large variety of climate characteristics. Contemporaneously, available climate parameters data series are in majority short and restricted to about a dozen points on the archipelago area, located mainly in coastal zones.

On the other hand, a series of Terrain Surface Temperature (LST) measurements recorded from the satellite level are available. The length of these series, their spatial resolution and frequency of measurements make them an attractive alternative to air temperature data or the source to fill their losses. This study attempts to answer the following question:

Can the LST values based on satellite data be used to model spatial distribution and seasonal variability of Svalbard air temperature?

In this work the LST from MODIS sensor contained in MOD11A1 and MYD11A1 products and the monthly average AT data obtained for the 38 measurement stations existing in Svalbard in the years 2000-2019 was used (approximately 3750 station/months).

LST may be used with success to model spatial distribution of air temperature (AT) over Svalbard. Simple regression AT-LST model is unbiased and the estimation standard error (SE) is about 2.0°C. The use of additional explanatory variables and more sophisticated modelling techniques made it possible to reduce the SE to 1.6°C. The additional variables, ordered according to their significance, include the month and type of LST spatial distribution (qualitative variables), Y coordinate of the position, height above sea level, LST standard deviation, distance from water and sea and the X coordinate of the position.

## **5106 Experiences, challenges and future perspectives of meteorological observations in the Arctic**

**Øystein Godøy, Ketil Isaksen, Cecilie Stenersen, Kjetil Stiansen\***

Norwegian Meteorological Institute, Oslo, Norway

In order to understand and predict environmental conditions in the ocean, cryosphere and atmosphere at different time scales, regular and long-term observations are required. In the Arctic, environmental conditions are rough and challenging for sustained monitoring. Furthermore, data communication is expensive which prevents real-time monitoring and thus limits downstream service provision.

Satellite remote sensing can to a certain degree compensate for sparsely distributed in situ observations, but not fully. Proper usage satellite remote sensing techniques require calibration and validation against in situ data, also in the interior of the Arctic. In order to sustain in situ monitoring the following aspects has to be addressed: cost, survivability, power and communication. Many of the existing approaches today are too expensive to become a sustained observing network with sufficient density.

Observing networks are relying on comparable observations all over the network. MET is operating under the observation protocols defined by World Meteorological Organization. These are not necessarily suitable for Arctic operation. Emerging requirements on in situ measurements (e.g. numerical simulation communities requiring new types of observations) continuously challenges power supply and data communication. Since 1986 MET has operated a network of remote surface stations with focus on weather forecasting and climate monitoring in Svalbard. The network now consist of 8 remote surface stations in addition to surface stations in Longyearbyen, Ny-Ålesund and Hornsund. Experiences from maintenance of this network and future perspectives and challenges are presented.

## **5108 Geodynamic Significance of Ice-Age Volcanism on Svalbard**

**Alexander Minakov\***

University of Oslo

Svalbard, as a part of the uplifted passive continental margins of northern Eurasia, has a central role in the development of tectonic and ice-sheet models of the polar North Atlantic and Arctic regions. The bathymetric changes of tectonic origin had a large impact on the deep water mass exchange between the Arctic and North Atlantic, global ocean circulation and climate through the Cenozoic era. Several episodes of Late Cenozoic uplift and volcanism younger than 10-15 Ma are widely recorded in northern Svalbard. The rugged topography and active crustal deformation has resulted from both Pleistocene glacial erosion and tectonic uplift owing to convective thinning of the underlying mantle lithosphere. The indicators of active tectonics continuous through the Late Cenozoic to the present time are: elevated temperature gradients measured in boreholes drilled in central Spitsbergen (~40-50 °C/km), hot springs in the Bockfjord region, strong intraplate seismicity and active faulting. Moreover, Spitsbergen Microplate has been previously identified based on seismological and geodetic data. This interpretation suggests that the microplate separates from Eurasia along an incubating shear zone following the trend of a long-lived zone of deformation

running across the Svalbard islands. If this interpretation is robust, we may witness today a development of new plate boundary bisecting Svalbard along an old suture zone reactivated during the last Ice Age period. The centre of the early onset of glaciation and the glacial erosion was likely pre-conditioned by the tectonic uplift associated with the Neogene and Quaternary volcanic centres in northwest Svalbard. The intriguing indications of possible correspondence of the chronology of glaciations and the volcanic activity on Svalbard (mid-Miocene and Quaternary) invite to explore possible links and feedbacks between glacial and geodynamic/solid-earth processes.

## **5109 Glacier Mapping and Wind Estimation with UAVs on Svalbard**

**Richard Hann\* (1), Andrew Hodson (2), Marius Jonassen (2)**

(1) Norwegian University of Science and Technology (NTNU); (2) University Centre in Svalbard (UNIS)

This study focusses on the application of unmanned aerial vehicles (UAVs) to study crevassed glaciers on Svalbard (RIS-ID: 11148). Drones have several advantages for this type of research. They offer a possibility to investigate crevasses from a safe distance, without the hazards of glacier travel. Drones can take high-quality aerial imagery and are mostly independent of cloud coverage, which is an advantage compared to conventional remote sensing satellite data.

Three tidewater glacier fronts on Svalbard have been mapped using a DJI Phantom 4 Pro drone: Tunabreen, Fridtjovbreen, and in Mohnbukta. For each location, we have generated high-resolution digital elevation models (DEMs) using a photogrammetry method. We use these DEMs to study the influence of surface roughness on atmospheric heat exchange. The aerodynamic surface roughness parameters, which are enhancing heat transfer rates, are strongly linked to the size, depth, orientation, and the number of crevasses. The aerodynamic surface roughness can be identified from the DEMs and is used in thermodynamic models to estimate the heat transfer rates. In the context of rising atmospheric temperatures due to climate change, crevasses may be an important factor for glacier mass balancing.

Furthermore, we have tested a novel approach to use a multirotor drone for wind measurements based on the UAV inertial measurement unit (IMU) data. Pitch angle, yaw angle, and thrust variables can be used to estimate wind speed and wind direction while the drone is holding its position. To calibrate the method and to find the estimation functions, the drone is flown next to a wind measurement mast near Longyearbyen. Once a function between the IMU data and the wind speed has been established, the drone was used to take vertical wind profiles up to altitudes of 120m above ground.

## **5110 Holistic, knowledge-based and sustainable planning and development; methods and tools for information, dialogue and co-creation**

**Lisbeth Iversen\***

NERSC/ INTAROS, AHO

Through the analytical perspectives of linking and bridging social capital, placemaking, participation and democracy, and through an Asset Based Community Development( ABCD) approach, I argue there is a need for co-creation, broad knowledge, and a facilitation of these processes in order to

reach the UN sustainability goals, and to secure a safe and holistic management and development. UN goal 17 is stating that collaboration is needed in order for countries and local communities to reach the UN sustainability goals. I base my action research partly on experience and approaches from the INTAROS-project ( Integrated Arctic Observing Systems-Horizon 2020)- where we are stating as one of the main objectives that knowledge-based planning of the future is required, in order to strengthen the societal and economic role of the Arctic region, and to support the EU strategy for the Arctic and related maritime and environmental policies. Building on experience from Arctic community-based monitoring programs, comparing top-down, (non-) governmental program driven approaches with bottom-up approaches, connecting these two approaches, and linking to Indigenous and local knowledge, can yield substantial benefits from local- to global scale observing programs. In addition the experience from my ongoing PhD work, (AHO) and action research, where I address mobilization of people and cultural resources for sustainable development, shows that it is easy to say “ collaboration” and “co-creation”, but HOW to do it is more challenging. As part of my PhD project I have contributed to an analysis of methods and tools for how to share information among stakeholders, establish dialogue and sharing knowledge, and how to make co-creation possible. I will present a guide to around 40 tools and methods of participation and co-creation that will help in the practical work of building trust and understanding among stakeholders.

## **5111 Testing snow models for an operational snow mapping product for Svalbard**

**Tuomo Saloranta\* (1), Trygve Aspelien (2), Jess Andersen (1)**

(1) Norwegian Water Resources and Energy Directorate (NVE); (2) Norwegian Meteorological Institute

Up-to-date information on snow conditions is a crucial element in forecasting of natural hazards such as avalanches, slush flows and snow melt floods. Operational daily updated maps of simulated snow conditions have existed already for 15 years for mainland Norway (see [www.senorge.no](http://www.senorge.no)). However, no such detailed and spatiotemporally well-covering information on snow conditions on Svalbard exist currently, despite the obvious relevance and need for such snow information in, for example, natural hazard forecasting on Svalbard and planning of outdoor and tourism activities. We present the first results from a comparison between high-resolution snow mapping products for Svalbard from three different snow models, all using the same 3-hourly meteorological forcing from the AROME Arctic numerical weather prediction model (NWP) as their input. The three tested snow models are (1) the single-layer seNorge snow model, applied by NVE for snow operational mapping in mainland Norway, and (2-3) the single- and multi-layer snow schemes D95 and ISBA-ES available in the AROME NWP model operated by MET. The suitability of the models and the input forcing for operational snow mapping for Svalbard is discussed, as well as suitable observation data sources for evaluation of the simulated snow conditions.

## **5112 Satellite-based SAR versus visual direct observations: an intercomparison of the two techniques for sea ice observations in Kongsfjorden**

**Dmitry V. Divine\***, Malin Johansson, Olga Pavlova, Sebastian Gerland\*, Anthony Paul Doulgeris, Anca Cristea, Svetlana Divina, Jean Negrel, Eirik Malnes, Tom Rune Lauknes

Norwegian Polar Institute, Fram Centre, Tromsø; UiT The Arctic University of Tromsø, NORCE, Tromsø

Seasonal sea ice covering parts of Svalbard fjords in winter and spring is important for regional and local climate processes, and for parts of the Arctic the ecosystem. Svalbard fjord ice features a range of ice types, and it is also a good testing ground for sea ice remote sensing techniques. This specifically applies to new/thin ice types that are difficult to discriminate from open water conditions. In this study we test the capability of a new sea ice segmentation and classification method that separates open water from sea ice using synthetic aperture radar (SAR) imagery from the ERS-1/2, Envisat ASAR, Radarsat-2 and Sentinel-1 satellites.

The extent of winter and spring sea ice cover in the fjords of western Svalbard has substantially declined over the last two decades, and has been the focus of a number of studies on effects of climate change on fjord marine environments and ecosystems. In the framework of the activity on fjord sea ice monitoring, visual observations of ice conditions in Kongsfjorden have been conducted from Zeppelin observatory on a nearly daily basis since 2002.

In this study we conduct a quantitative intercomparison of local sea ice extent SAR satellite retrievals over the period 2003-2018 with results from detailed visual observations of sea ice in the fjord. When possible, the results from both methods are also compared with tracked ice edge positions from boat-based surveys and optical imagery from Landsat and Sentinel-2 satellites. The effects of various ice types on reconstructed ice edge positions and hence the ice area is explored, whilst considering uncertainties specific to visual observations. Challenges such as distinguishing between open water with variable wave conditions, sea ice and icebergs, growlers and bergy bits originating from nearby glaciers together with the general effects of weather on SAR retrievals are also discussed.

## **5113 Enhancing an observing system for Svalbard through recommendations from Earth System Science researchers**

**Shridhar Jawak\***, Inger Jennings, Christiane Hübner, Bo Andersen, Øystein Godøy, Heikki Lihavainen

Svalbard Integrated Arctic Earth Observing System (SIOS)

The State of Environmental Science in Svalbard (SESS) is an annual report produced by Svalbard Integrated Arctic Earth Observing System (SIOS), a Norwegian initiated consortium of 25 institutions from 10 countries. The SESS report 2018 contains 9 chapters contributed by 44 authors from 39 international institutions. It summarises existing monitoring and ongoing work to optimise the observing system and highlights the questions that remain unanswered. Crucially, SESS recommends possible solutions to optimise research infrastructure and data collection in Svalbard to address key Earth System Science (ESS) questions. The report covers all the spheres of the Earth system, from the deep permafrost through the surface interfaces, into the ocean and to the upper atmosphere

approaching space. Some of the recommendations in SESS 2018 are: (1) Improve knowledge and cross-disciplinary actions to establish a holistic picture of snow processes and ways to monitor their effects; (2) Extend the network of marine observatory measurements and encourage collaboration, communication, and planning of future marine observatories; (3) Establish high-quality, long-term observations of the lower atmosphere at geographically diverse sites around Svalbard; (4) Implement permafrost observations in northern and eastern parts of Svalbard; (5) Link microbial activity to existing measurements of climate-active gas fluxes at several locations in Svalbard; (6) Standardised data formats are essential to stimulate efficient collaboration within a broader community, including ESS modellers. These recommendations highlight knowledge gaps, gaps in research infrastructure, sites for possible expansion of infrastructure, and the current state of the core in-situ data available to address broad ESS questions. The next step is to implement these recommendations by coordinating the efforts of SIOS member institutions, whilst promoting a sustainable approach to reducing the environmental impact of research such as co-location of instruments for scientific observations and reducing redundant observations concentrated to specific areas in Svalbard.

## **5115 Distributing temperature Sensing (DTS) measurements of the Arctic atmospheric boundary layer at the AWIPEV station in Svalbard**

**Marie-Louise Zeller\***

Alfred Wegener Institute Potsdam

Distributing Temperature Sensing (DTS) is still a very new and exciting measurement technique in atmospheric research to measure highly resolved temperature as a function of space and time. As part of my master thesis at the Alfred Wegener Institute in Potsdam I will utilize the DTS technique to investigate the physics of Arctic atmospheric boundary layer (AABL) at the AWIPEV station in Svalbard. I will focus on the investigation of the spatial structure of the AABL and one aim of the campaign is to improve the utilization of the DTS technique for future applications in boundary layer research. The DTS technique uses Raman spectroscopy to highly resolve the temperature along fiber-optic cables in the range of several kilometres. Hence it allows resolving the spatial structure of turbulence elements within the AABL. Understanding turbulence in the AABL is a very important and highly relevant issue for the parametrization in atmospheric climate models and so for the prediction of the future climate. There is still a big lack of understanding especially of the stable layered AABL during the Arctic winter. The poster will present the planning, the goals and the challenges of the planned field campaign in Svalbard from mid-February to mid-March 2020.

## **5116 A Researchers Guide to Ny-Ålesund**

**Christina A. Pedersen (1), Helge T. Markussen\* (1), Vera Sklet (1), Geir. Gotaas (1), Svein Harald Sønderland (2), Susanne Wasa Hagen (2)**

(1) Norwegian Polar Institute; (2) Kings Bay

Ny-Ålesund is the world's northernmost year-round research station, and an important Norwegian platform for international research. Well-established international collaboration, advanced research infrastructure and excellent science are the building stones of this world leading observation and research platform for natural sciences. International research activity and cooperation is extensive in



Ny-Ålesund, with more than 20 research institutions engaged in long-term research and monitoring activities. With the station's new research strategy, the Norwegian Polar Institute (NPI) has been assigned the role of being Norway's host. NPI has also been tasked with the implementation and daily follow-up of the research strategy on-site, as well as with serving as the point of contact for national and international research activities. The company Kings Bay AS owns the land and most of the buildings in Ny-Ålesund, and provides infrastructure support services for research and monitoring activities in the area.

To assist researchers (both those new to the station, and those with experience) coming to Ny-Ålesund, NPI and Kings Bay have developed the "Researchers Guide to Ny-Ålesund". This guide is designed to help researchers with the entire process of planning and executing a project in Ny-Ålesund; from the first development of a project, to booking of the stay and preparing for field work, to the actual work on site, and the follow-up after. The guide also provides general visitor information. We hope the guide will contribute to maximising the scientific output for each and every researcher coming to Ny-Ålesund Research Station. The guide is published on the webpage for Ny-Ålesund Science Managers Committee (NySMAC): <http://nysmac.npolar.no/research/researchers-guide.html>, and a short version will be presented at this poster. Welcome to Ny-Ålesund Research Station!

## **5117 A new GIS system for Ny-Ålesund**

**Christina A. Pedersen\*, Helge T. Markussen, Vera Sklet, Geir. Gotaas**

Norwegian Polar Institute

The process of planning and coordinating fieldwork, while avoiding affecting past or ongoing field experiments, and the effort of maximising scientific output from measurements would both benefit considerably from a common geographical information system (GIS) for Ny-Ålesund.

As part of the Norwegian Polar Institute's new role in Ny-Ålesund in implementing the new research strategy, NPI has initiated the development of a GIS system for Ny-Ålesund. The Ny-Ålesund GIS will be used to register information about past and current installations, instruments, manipulations and environmental incidents. In addition to being an important tool for the planning and coordination of terrestrial and marine fieldwork in the Ny-Ålesund area, the new GIS will be part of the environmental impact assessment work.

The system will consist of an adjusted map client for Ny-Ålesund with a graphical user interface similar to *Svalbardkartet*. The system will give access to the same background information and map-layers as in *Svalbardkartet*, but also new map layers with Ny-Ålesund information, and a new interface to facilitate the registration of new information from Ny-Ålesund

A NySMAC working group has been established to collect user requirements and develop the data model for the new Ny-Ålesund GIS. Information on instruments, installations and field sites will be collected from all institutions present in Ny-Ålesund, and included in the first version of the GIS system. This poster will present the GIS prototype and open up for input and comments from the research community. When up and running, the system will be available for all researchers with interest in Ny-Ålesund.

## **5118 Mapping plant functional groups, traits and degradation in the High Arctic using multispectral UAV imagery**

**Eleanor Thomson\***, Marcus Spiegel, Marc Macias-Fauria, Yadvinder Malhi

University of Oxford

The tundra is the fastest warming ecosystem on Earth, experiencing changes in plant species, trait distributions and vegetation health. The potential for soil carbon loss is particularly great in high-latitude regions, thus changes in vegetation properties will have global consequences due to feedback effects involving soil temperature, decomposition rates and carbon cycling. Ecosystem maps are foundational tools which can be used to determine environmental controls on vegetation and provide a baseline to measure change. Here we present continuous vegetation maps for three sites in Svalbard at <10cm resolution. The maps were created using 5-band multispectral imagery taken using a MicaSense RedEdge mounted on a UAV (unmanned aerial vehicle). Using Random Forest Classification, we were able to map plant functional groups across the three sites. Using partial least squares regression, we were able to map plant water content and vegetation degradation at the landscape level. Results were calibrated and validated on >90 turf samples collected during Plant Functional Traits Course 4. The turf samples were analysed for their species ID, trait values and state of health. Compared to hyperspectral measurements (400-2500nm) taken with a spectrometer on the same turfs, the 5-band UAV imagery quantified all vegetation properties with a lower but promising accuracy. As UAVs and multispectral sensors continue to decrease in price, we conclude that UAV 5-band imaging may provide a robust, cost-effective method for high resolution mapping of tundra vegetation and could be used to bridge the gap between field and satellite remote sensing measurements.

## **5119 Critical times: Calving habitat selection and site fidelity in a High-Arctic ungulate**

**Ingrid M. G. Paulsen\***, Eeva M. Soininen, Virve Ravolainen, Leif Egil Loe, Brage B. Hansen, Steve Albon, Justin Irvine, Audun Stien, Erik Ropstad, Vebjørn Veiberg, Mads Forchhammer and Åshild Ø. Pedersen

Norwegian Polar Institute; UiT - Arctic University of Norway; NTNU; The James Hutton Institute, NINA; UNIS

While giving birth to a viable offspring mainly depend on maternal condition, behavioral decisions on parturition location may be decisive for offspring survival in the days following birth. For many ungulates, predator distribution, insect stressors, human disturbance and forage availability influence female habitat selection and calving site fidelity in the critical calving period. The high-Arctic solitary Svalbard reindeer (*Rangifer tarandus platyrhynchus*) is a keystone herbivore on the archipelago, and have evolved without predators, minimal insect stressors and human disturbance. Here we estimate immediate calving locations, assess determinants of calving habitat selection and site fidelity using a GPS dataset (2009-2017) of females with differing reproductive status from two landscape and climate contexts (coast vs. inland populations). Applying movement-based methods we identified parturition locations for 66 individuals and demonstrated that female reindeer with and without calves in inland populations selected for calving locations with high forage quality and quantity on flatter and lower elevated grounds, while females in coastal populations had high individual variability in calving habitat selection. Females with calves in inland populations displayed

high site fidelity to former locations during the calving period (2.-16. June; 95% CI: 2.0-3.6 km, N=19) compared to pairwise distances in other seasons (95% CI: 3.1-5.5 km). Regardless of reproductive status, site fidelity to former locations increased from calving to late-summer (August). We were unable to test site fidelity for females in coastal populations due to few individuals with two calving seasons. Our results indicate that Svalbard reindeer females select environments associated with good foraging conditions during the calving period, and that resources in former calving locations appear important for parturient females. This study is the first to provide knowledge on calving locations and habitat characteristics for Svalbard reindeer, and can provide management with information to restrict human activity within areas critical for Svalbard reindeer reproduction.

## **5120 ArcticDEM for glaciological studies: intercomparison between geodetic and direct mass-balance measurements at Aldegonda glacier (Nordenskiöld Land)**

**Anton Terekhov\*, Gleb Tarasov, Olga Sidorova, Vasiliy Demidov, Mikhail Anisimov, Sergei Verkulich**

Federal State Budgetary Institution «Arctic and Antarctic Research Institute» (Saint Petersburg, Russia)

Aldegonda is a mountain valley glacier located 10 km southwest from Barentsburg, at the western coast of Grønfjord (Nordenskiöld Land). Since the 30s of the past century, when the observations of its termini positions were started, the glacier retreated from the coast over the distance of about 2.5 km, or, roughly, for half of its length. Nowadays Aldegonda glacier covers an area of about 6 sq km.

We estimated cumulative mass balance of Aldegonda glacier in the period from July 2015 to August 2018 using geodetic methods with verification by glaciological measurements. Geodetic mass balance was calculated based on the difference between topographic survey of the glacier surface and ArcticDEM, derived from WorldView imagery. During the same period glaciological measurements of ablation stakes were carried out. Since there was almost no snow cover on the glacier in the summer, we recalculated surface lowering in the mass budget values through multiplying by the ice density.

As the result, we obtained almost the same range of specific balance from the snout to the top using two methods (around  $-3.00$  to  $-1.10$  m w.e./year). However, mean mass balance value is overestimated by glaciological measurements relative to ArcticDEM-based results ( $-1.81$  vs  $-1.76$  m w.e./year, respectively). Thus, the estimation of cumulative mass loss over the period 2015 to 2018 also varies: 31.2 Mt (glaciological data) versus 30.3 Mt (geodetic data).

The difference between results obtained using two different approaches can not be related solely with vertical inaccuracies of ArcticDEM, as it comprises also the uncertainties of stake measurements and interpolation. Thus, our study shows that usage of ArcticDEM gives sufficient results compared to ground-based glaciological method at the scale of single glacier, and therefore has a high potential for the glaciers mass balance investigations.

## **5121 Towards a temporally and spatially resolved Nested Exposure Model for organic contaminants in Arctic ecosystems**

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There is concern over possible effects on Arctic ecosystems from exposure to persistent organic pollutants (POPs) and contaminants with similar properties. Svalbard has for years been a hotspot for field-based research on exposure and effects of POPs in Arctic wildlife. However, to enable scientifically sound response strategies, a mechanistic understanding of the complete link between chemical emissions on a global scale and resultant concentrations in Arctic ecosystems is fundamental. We hypothesize that this understanding can be improved by combining empirical data with mechanistic models of contaminant fate and behavior. The main objective of this study is to develop, evaluate, and apply a new Nested Exposure Model (NEM) consisting of (i) a global spatially and temporally resolved module for contaminant fate in the physical environment and (ii) a bioaccumulation module for organic contaminants in ecosystems typical for the Svalbard and Barents Sea area. The bioaccumulation module includes zooplankton, selected fish species, ringed seal, beluga whale, lichen, reindeer, and humans, and is currently under development to include key Arctic top predators including seabirds and polar bear. This presentation will give an overview of the NEM model. Initial evaluation of the bioaccumulation module for selected polychlorinated biphenyls (PCBs) suggests that predicted concentrations agree well with measured concentrations across species and time. A preliminary exploration of connecting the two modules of NEM to model spatial variation of Arctic ecosystem exposure will also be presented. NEM has considerable potential for future applications, and will be further developed and applied in a new interdisciplinary project investigating combined effects of contaminants and climate change on Arctic ecosystems in the Svalbard and Barents Sea areas. In the future, we hope that NEM will be a useful tool for both scientific and regulatory communities interested in understanding and protecting ecosystem and human health from legacy and emerging organic contaminants.

## **5122 Improving our understanding of Arctic clouds: multi-instrument, multi-frequency, and combined modeling-observation approaches**

**Kerstin Ebell\* (1), Vera Schemann (1), Stefan Kneifel (1), Tatiana Nomokonova (1), Rosa Gierens (1), Marion Maturilli (2), Christoph Ritter (2)**

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Arctic clouds are still challenging for both observations and modeling. High quality observations are needed to better understand the processes related to Arctic clouds and their role in affecting the Arctic climate. Only a few sites exist in the Arctic, where continuous cloud observations with a high vertical resolution are performed. One of these sites is the French - German Arctic Research Base AWIPEV at Ny-Ålesund / Svalbard, where a cloud radar has been installed as part of the Transregional Collaborative Research Centre TR172 on Arctic Amplification (AC)<sup>3</sup> ([www.ac3-tr.de](http://www.ac3-tr.de)) in 2016. In this presentation, we will highlight ongoing and upcoming (AC)<sup>3</sup> cloud research activities at Ny-Ålesund and the need to tackle the cloud problem by various means.

Each remote sensor, e.g. a single-frequency cloud radar, already provides valuable information on cloud properties such as cloud occurrence or vertical structure. However, more complex properties such as cloud phase, ice particle habit, detection of rimed or aggregated particles, require the combined use of different approaches. Sensor synergy is thus crucial to get a much more comprehensive picture of Arctic clouds and the related microphysical processes. In particular, the combination of different frequencies (combined 94 GHz and 35 GHz cloud radar), radar polarimetry, and lidar will provide the necessary observational constraint for processes in Arctic mixed-phase clouds which is needed to evaluate and improve numerical models.

Using a high-resolution model, we can perform sensitivity experiments and test different microphysical parametrizations relevant for Arctic cloud processes. In order to link observations with models, we also need a forward operator which simulates synthetic observations based on the model output. In this way, we can better understand the sensitivities of our observations and the role of specific microphysical processes. Long-term model-observation statistics will be combined with detailed analyses of specific case studies.

## **5123 A new airborne remote sensing platform at Svalbard (id 5123)**

**Agnar Sivertsen\*, Daniel Stødle, Stian Solbø and Rune Storvold**

NORCE

The LN-LYR, one to the two Dornier passenger aircrafts operated by Luftransport at Svalbard, has recently been upgraded with a sensor pod. The pod contains a high resolution hyperspectral imager (VNIR-1800, Norsk elektro ptikk), a medium format aerial camera (IXU-150, Phase One), an AIS receiver (Kongsberg Seatex), a high bandwidth data link (Radionor CRE2-179 UAV) and a GNSS-inertial navigation system (Applanix posav 410) for direct georeferencing of the recorded data. The data recording and tasking system is developed by NORCE and designed for being operated autonomously during normal flights. It is, to our knowledge, the only passenger aircraft with this capability. The aircraft upgrade is part of a four-year project, partly funded by the Troms county, where the focus is on developing new technology and solutions for airborne surveys and rapid processing and sharing of data from airborne platforms. In addition, new methods and technology for collaboration and real time interaction with data from multiple platforms and sources, such as UAVs, ships and buoys, are being developed in the project. New capabilities for sea ice monitoring and search and rescue are two specific applications that will be demonstrated using the Dornier platform at Svalbard.

The payload is partly funded by the Svalbard Integrated arctic earth Observing System Infranor project and will contribute to time series of high resolution hyperspectral transects as the aircraft flies weekly to Ny-Ålesund and about 20 transects a year across from Longyearbyen to the Villum Research Station (Station Nord) on Greenland to provide logistical support. Sea ice concentration, spectral albedo, chlorophyll-a, algae concentrations and ocean waves are some parameters which can be retrieved from the optical data. These data will also provide valuable validation for satellite data retrievals. The high bandwidth datalink will be used for uploading high bandwidth data from drift and sail buoys, and for real time collaboration and coordination of data retrievals by ships and other vessels operating north of Svalbard.

The pod is designed for future upgrades and there are currently room for a synthetic aperture radar, a short wave infrared hyperspectral imager and a thermal camera. Other instrumentation, such as a laser scanner and a EO/IR gimbal, can be fitted on the aircraft itself. The newly upgraded Dornier is an ideal and cost effective multitool for remote sensing missions on and around Svalbard. We believe it will bring new opportunities and interesting discoveries for the Svalbard science community for years to come.

## **5124 ALADINA – a mobile, flexible tool to study the spatial distribution of aerosol particles in the Arctic environment**

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Aerosol particles in the Arctic play a crucial role when investigating the global warming. Here, the role of new particle formation (NPF) and long range transport or potential of other sources needs to be quantified to understand the influence on cloud formation and radiation budget.

To investigate the spatial distribution of aerosol particles in an Arctic environment and to detect potential NPF events a four week measurement campaign was conducted with two different types of unmanned aerial systems (UAS) between April and May in 2018 in Ny-Ålesund (Spitsbergen, Norway). The UAS ALADINA is equipped with miniaturized aerosol instrumentation (2 condensation particle counters with different lower detection limits, optical particle spectrometer, aethalometer) and meteorological sensors. Turbulence sensors are mounted on the UAS MASC 3 in order to study the possible impact of turbulent properties on the NPF. Around 200 vertical profiles were performed with the UAS ALADINA between ground and 850 m agl, thus connecting the ground measurements at Gruvebadet and the data sampled at the Zeppelin observatory at the height of 474 m above sea level. Further measurement flights were operated horizontally above snow cover and above open water in order to capture the possible impact of biogenic activity on the NPF.

NPF was observed frequently, on 55% of the measurement days during the course of the campaign in 2018. Here, different cases were found: NPF starts partly on ground and grows to higher altitudes but there were also cases with NPF in a distinct layer between ground and Zeppelin observatory leading to the result that none of the ground stations has observed the event. The vertical distribution of  $N_{<20}$  is furthermore strongly affected by different wind fields resulting from the complex terrain at site.

## **5125 SIOS Data Management System ( SDMS) : A tool for increased collaboration in Svalbard research**

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Svalbard (71°–81°N, 10°–35°E) is a region affected by a large climate gradient, alternately influenced by cold central Arctic or mild marine climate conditions at time scales of weeks to years, causing strong in- and outflows between the Arctic and mid-latitudes. The existing infrastructure makes Svalbard a very accessible location for cost-efficient studies of the unknowns in the climate puzzle.

Svalbard Integrated Arctic Earth Observing System (SIOS) is a regional observing system for long-term collection and proliferation of fundamental knowledge on global environmental change in an Earth System Science perspective. SIOS is, through the international cooperation of its 24 member institutions, monitoring atmospheric, terrestrial, cryospheric, ocean and sea ice composition, conditions and variability in the region of Svalbard. To better understand the complexity of the climate system, a prerequisite is to have a complete overview of the existing data and their availability. The SIOS Data Management System (SDMS), developed by the SDMS Working Group, is harvesting information on historical and current datasets from collaborating thematic and institutional data centres and making them available to users. SDMS is currently serving more than 900 datasets to users through a central data catalogue ([https://sios-svalbard.org/metadata\\_search](https://sios-svalbard.org/metadata_search)). The primary information resource are the data repositories maintained by SIOS partners. Integrity of the information and harmonisation of data hosted by the contributing data centres is based on the world wide accepted protocols assuring interoperability of data, standardised documentation of data (through use of metadata) and standardized interfaces provided by data systems (through discovery of metadata). In order to properly describe the existing infrastructure producing data, SIOS has also established a catalogue of observation facilities (<https://sios-svalbard.org/sios-ri-catalogue>). The status of the SDMS and its relation to Arctic, European (e.g. ENVR-FAIR) and global data management frameworks is presented.

## **5201 Arctic Water Isotope Cycle processes and patterns in the Central Arctic during an International Arctic Drift Expedition (MOSAiC)**

**Jeff Welker\*, Eric Kleine, David Noone, Hannah Bailey, Kaisa Mustonen, Ben Kopec**

University of Oulu, Finland

The largest ever international Arctic research endeavor, MOSAiC, is now operational. This once in a generation expedition is based in large part on the year-long drift of the Polarstern icebreaker from the Eastern Arctic, across the N Pole and down through the Fram Strait in to the Barents Sea. The ship-based and accompanying land-based studies have research teams addressing a suit of attributes throughout the entire year that focus in large part on cyrosphere-atmosphere-oceanic processes. As part of the MOSAiC Atmosphere-Cryosphere Interaction research program, we have an international team that focuses on the Arctic Water Isotope Cycle. We now have a network of water vapor isotope

stations that are both ship- (Polarstern icebreaker) and land-based (NyAlesund-Svalbard; Arctic-Finland; Nord, Thule and EGRIP-Greenland; Krycklan-Sweden; Toolik Lake and Barrow-Alaska) collecting a transformational set of observations and measurements during MOSAiC and beyond, into to Nansen Legacy Program.

Understanding the interactions between the bi-directional fluxes of moisture (ocean water and water vapor) into and out of the Arctic through the Fram Strait (water way between NE Greenland and W Svalbard) is one of the highest priorities of Arctic atmosphere-sea ice-ocean current interaction research today and is thus a primary objective of our project. This region is where two major ocean currents and water vapor moisture sources flow in reverse directions simultaneously (like a two way street); with divergent isotopic finger prints, varying degrees of intensity and an unknown amount of interaction with sea ice. Understanding these fluxes and how they interact, change with higher or lower sea ice extent, and have been manifested in climate records (i.e., ice cores) are central to modeling and forecasting changes in the Arctic, especially in the Barents Sea region. Data from Arctic Finland, Greenland, Alaska and NyAlesund will be presented.

## **5202 Using long-term monitoring data to estimate and model species resilience across a warming Arctic**

**Mads Forchhammer\***, Anna Ejsmond

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The accelerating warming across the Arctic poses an increasing threat to the existence of the current communities of Arctic species. Not only because of the increasing average temperature but, in particular, the accompanying increase in variance. Indeed, more frequent extreme events will push Arctic species inherent co-variance of their ability to time life history events optimally of accelerating environmental cues.

Increased number of studies have demonstrated through trend analyses of time-series a close co-variation between timing of climatic events, such as snow melt, and timing of life history events in Arctic species. However, valuable as they may be, analyses of trends focus on the influence of extrinsic factors only, without integrating evolutionary settings ofb species phenology. Indeed, biological time series are known to display significant autocorrelation without white noise, indicating the importance of species inherent ecological responses to changes.

Here, we present, a novel analytical framework to estimate and model species resilience to climatic changes from current long-term monitoring programmes across the Arctic. Although we exemplify our approach using flowering phenology time series, we argue that our approach using autoregressive time series analyses may be employed to a broader range of types of time series across biology and climatology.



## **5203 Microclimatic features of Barentsburg and Pyramiden area. Modern and historical data**

**Boris Ivanov\* (1,2), Pavel Sviashchennikov (2,1), Ulyana Prokhorova (1), Aleksandra Urazgildeeva (2,1), Katarina Zotova (2,1), Oksana Mankova (2)**

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The features of the microclimate in the Russian settlements of Barentsburg (Grønfjorden), Pyramiden (Billefjorden), as well as on the Aldegonda glacier (Grønfjorden) are considered. The studies were carried out as part of a joint scientific program between the Norwegian Meteorological Institute (Oslo) and the Arctic and Antarctic Research Institute (Saint-Petersburg) in 2014-2016, as well as in framework of the SSF field project (<http://www.researchinsvalbard.no/project/8532> RIS-ID10803 "ORGANIZATION AND CONDUCTING OF MICROCLIMATIC OBSERVATIONS ON THE GLACIER OF ALDEGONDA 2015-2018, 2019-2021). Simultaneous (synchronous) measurements of air temperature in Barentsburg were carried out at three points: at the modern meteorological site of the Barentsburg research station (1984 - present, height above sea level - 74 m), at the previous position (1974-1984, height above sea level is 20 m) and at Cape Finneset (Norwegian meteorological station "Spitsbergen-Radio, 1911-1930, height above sea level 8 m). The main goal is to obtain homogeneous time series of meteorological variables, covering the entire period of instrumental observations in the region of Barentsburg. Analysis of a homogeneous series of observations allowed us to correctly assess the long-term changes in air temperature in Barentsburg over the period 1911–2019. Synchronous observations in the Pyramiden were carried out in the winter of 1988-1989 at the place of the conserved Soviet meteorological station (1948-1957, 11 m above sea level) and at an altitude of 400 m above sea level on slope of Pyramiden Mountain. Such observations made it possible to study possible altitudinal changes in air temperature. Synchronous observations on the Aldegonda glacier and at the base station in Barentsburg were conducted at the foot (120 m above sea level) and at the top of the glacier (350 m above sea level). The obtained significant statistical relationships of changes in air temperature will allow us to estimate the magnitude of possible melting on the surface of the glacier using standard observations in Barentsburg.

## **5204 Permafrost monitoring network in Barentsburg as part of Eurasian Arctic high-latitude permafrost monitoring transect**

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The Russian Arctic scientific expedition on Spitsbergen performs permafrost observations in Barentsburg since 2016, including as a part of the Russian-German initiative to establish a Eurasian Arctic high-latitude permafrost monitoring transect covering the Spitsbergen, Franz Josef Land, Severnaya Zemlya, Novosibirskiye Islands and Wrangel Island. The permafrost monitoring network in Barentsburg includes: (1) four temperature monitoring boreholes of the Global Terrestrial Network for Permafrost with depth up to 26 m, (2) one site of the Circumpolar Active Layer Monitoring Network (CALM) for observing the dynamics of the seasonally thawed active layer equipped with an automatic meteostation, (3) a study area for repeated morphometric and temperature observations of a group of seven pingos, (4) the periodic observation and sampling of a number of groundwater

springs, ice blisters and icings, and (5) the periodic ground penetrating radar and electrical survey of glaciogenic and hydrogenic taliks.

The ground temperatures at a depth of zero amplitude vary from -2.2 °C to -3.56 °C. Quaternary drill core deposits, formed according to radiocarbon analysis during the period of MIS 3 - MIS 1, have a thickness up to 40 m. In the upper parts deposits are mainly represented by gravel with structureless cryostructure. The lower parts of the core sections are built by clay with streaky cryostructures. Clays are characterized by high salt content and thus freezing temperatures between -1 and -2 °C, which makes them highly sensitive to even slight ground temperature increase. The measurements of the active layer dynamics on a CALM site showed values from 1.15 to 1.60 m with an average of 1.38 m in 2017. The upper boundary of pingos ice body was observed at the depth 1.5 – 13.0 m, thus some of them are degrading or soon will start to degrade due to propagation of 0 °C isotherm to the ice.

## **5205 Comparing of atmospheric circulation features on the warming period in the 1920-th and modern warming period in the Barents sea region**

**Uliana Prokhorova\*, Pavel Sviashchennikov, Boris Ivanov**

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The results of investigation of temporal variability of atmospheric circulation in the Western Arctic region (Norwegian – Barents Seas) are presented. The daily archive of atmospheric circulation form (Wangengheim- Girs, 1891-2016) was used for characterization of atmospheric processes.

The main attention was focused on assessment of discrepancies between weather conditions in the modern warming period and period in 1920 – 1950 years, which called like a first warming period in the Arctic. Tendencies of change of repeatability of the circulation forms are determined for the cold (November - April) and warm season (March - October). The recurrence of the number of days with the same form, which can be viewed as a characteristic of the stability of weather conditions during the warming periods under consideration, was calculated. The predominance of the frequency of occurrence of the circulation form W is characteristic for both periods of warming, both in the warm and in the cold seasons.

The current period of warming in the study area is characterized by an increase in the frequency of occurrence of the circulation form C of short duration compared with the period of the first warming. Accordingly, we can conclude about the current climatic regime, which is characterized by an increase in surface air temperature and at the same time has less stable weather conditions. Estimates are calculated by series of routine meteorological observations at Vardø, Bjørnøya, Tikhaya Bay and Hayes Island, showed that increasing in the repeatability of forms change and dangerous weather phenomena, such as increased wind speeds of more than 15 m/s isn't linked.

The research was carried out within the project: «Causes of the early 20th century Arctic warming», funded by the National Science Centre (Poland) and in frame of Joint Scientific Program between Norwegian Meteorological Institute and Arctic and Antarctic research Institute (2019-2021).

## **5206 Long-term (1985-2019) changes of High Arctic environment in the Svalbard climate gradient**

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The increase of air temperature in the Arctic in the last century was twice as large as on a global scale. Climate changes in the Arctic strongly affect the individual components of ecosystems (sea ice, glaciers, permafrost, flora and plant communities, fauna). Knowledge of these trends, however, is very diverse due to the type of the environment component and geographically. We know a lot about the changes in the range of sea ice and glaciers on the lands. Less is known about complex changes of whole environment including permafrost and vegetation, especially on the islands of the High Arctic. The aim of the present study was to use several spectral indexes from satellite images to assess long-term changes in tundra environment conditions (surface albedo, moisture status of soils, biological crust and green vegetation) for the three sites in the Svalbard archipelago located in a climatic gradient from marine to semi-continental cases.

The areas included in the analysis are located on a similar latitude (about 78°30'N) on a W-E transect with a length of about 130 km. The climatic gradient between sites is marked primarily in rainfall totals (from 200 to 400 mm annually), but also in average annual air temperatures (difference of 2-3°C) and in the temperature amplitude between seasons. For each of the areas included in the analysis, it was possible to collect about 30-50 good-quality images made in 1985-2019 by sensors installed on the Landsat series satellites (5, 7 and 8). Only images taken during the growing season were selected. The number and temporal distribution of satellite images allowed not only for comparisons between areas and identification of long-term trends, but also for the assessment of variability during the growing season and from year to year. As a complementary source of data MODIS sensor products (Terra and Aqua satellites) from 2000-2019 period were also used.

## **5207 Trace element concentrations in freshwater media in the Hornsund area of Svalbard**

**Filip Pawlak\* (1), Krystyna Koziol (1), Marek Ruman (2), Zaneta Polkowska (1)**

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Trace elements in the surface waters of Svalbard may originate from both natural and anthropogenic sources, and their concentration levels are of interest to gauge water quality for environmental reasons and for direct use. In this study, surface waters were collected in the vicinity of the Polish Polar Station in Hornsund (Svalbard) to determine their concentration of trace elements: Ag, Al, As, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Cs, Mo, Ni, Pb, Sb, Se, Sr, Tl, U, V and Zn. In the period from August to September 2010, 40 surface water (spring, stream and lake) and atmospheric precipitation samples were collected in various locations at the shores of the Hornsund fjord. Statistical methods such as principal component analysis (PCA) and cluster analysis (CA) were used to determine the similarity between samples taken. The contamination factor (CF) was also calculated and used to assess the extent to which the sampled water may be subject to pollution.

### **Acknowledgement**

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## **5208 Permafrost temperatures in Svalbard – establishing the next generation observations**

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The permafrost in Svalbard is the warmest this far north in the Arctic, and thus permafrost observations are important for understanding how the ground responds to Svalbard's current, rapid warming. As part of the Svalbard Integrated Arctic Earth Observing System (SIOS) - Infrastructure development of the Norwegian node (InfraNOR) project, we are working to further develop, upgrade and modernize the permafrost observation infrastructure in Svalbard. During winter 2019, we drilled 167 m of boreholes in seven different landforms, primarily in the Adventdalen area, using the medium-sized, upgraded UNIS permafrost drill rig. The average depth of the boreholes was 21 m. Permafrost cores were retrieved from 64 m. During summer 2019 we are establishing the first permafrost monitoring borehole at more than 80°N in Svalbard, next to the meteorological station at Verlegenuken, at the northernmost part of the Spitsbergen island. New digital thermistor strings will be installed in the new boreholes during autumn 2019, with planned operational real-time access to as many of the boreholes as possible. The collected permafrost data will feed into the Norwegian Permafrost database at the Geological Survey of Norway, and into the international Global Terrestrial Network for Permafrost (GTN-P) database. Once the UNIS permafrost drill rig is upgraded and tested during the first part of the InfraNOR project, it will become part of the accessible SIOS research infrastructure in Svalbard, based in Longyearbyen at the Svalbard Science Park.

## **5209 Long-term monitoring in The Ecosystem of Kongsfjorden, Svalbard**

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*The Ecosystem of Kongsfjorden, Svalbard*, in *Advances in Polar Ecology* 2019, includes several time series. The air temperature record in Ny-Ålesund extends back to 1940. Since the 1960's, the temperature has increased rapidly, and the years from 2005 to present were the warmest on record. The air temperature increased most during winter (3 °C per decade) within the monitoring period 1994-2017. Warming has also been observed in the fjord during its monitoring since 1994. Variations in Atlantic water (AW) content and vertical distribution in the fjord are related to advection. The increase in temperature that occurred after a massive AW-inflow in February 2006, which is considered a tipping point for Kongsfjorden, persisted for subsequent winters until the cold years 2009–2011. However, the period 2012–2016 revealed prevailing large volume of Atlantic water in the fjord during summer. This affected the distribution and thickness of fast ice in the fjord, recorded during 2003-2016. Before 2006, the sea ice extended into the central part of the fjord, but during the last decade the sea-ice extent was often reduced to the northern part of the inner bay. Maximum seasonal thickness of fast ice was 0.6 m or more prior to 2006 declining to 0.2 m in recent years.

Changes in environmental factors caused variations in bloom dynamics, biomass and species composition of phytoplankton during 2002-2014. The phytoplankton dynamics in Kongsfjorden followed the classic spring-bloom paradigm, with spring diatoms and the colony-forming haptophyte *Phaeocystis pouchetii*, followed by flagellates and their protozoan grazers during summer. Zooplankton recorded during 1996-2016 showed changes in species composition related to increase in Atlantic water and decrease in sea ice. Atlantic zooplankton increased in biomass, whereas the Arctic species declined or remained relatively stable. The total biomass of zooplankton has increased in the fjord implying potentially higher secondary production.

## **5210 Title Climate-Ecological Observatory for Arctic Tundra (COAT): Implementation of research infrastructure for ecosystem-based monitoring in the high-Arctic Svalbard**

**The core COAT Svalbard Project Team: Åshild Ønvik Pedersen\*, Eva Fuglei, Jean-Charles Gallet, Ketil Isaksen, Jesper Madsen, Virve Ravolainen, Eeva M. Soininen, Audun Stien, Leif Einar Støvern, Rolf A. Ims**

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The Climate-Ecological Observatory for Arctic Tundra (COAT) is an integrated ecosystem-based observation system aiming at real time detection, documentation and understanding of climate impacts on low- and high Arctic Norwegian terrestrial ecosystems. COAT uses the adaptive monitoring approach, having question and hypothesis-driven conceptual 'climate impact path models' at the core of the program. We aim to establish causal relations between food web components that are important to ecosystem functioning and/or management (response targets) and climate and management drivers (predictor targets). The models encompass key species and functional groups within the food webs and their mutual linkages. COAT builds on and expands the ongoing research and long-term in Svalbard, with focus on the Nordenskiöld Land and the Brøggerhalvøya regions, and is the core of the SIOS land module. The COAT team comprises multidisciplinary competence within geophysics and ecology, and includes sites and research teams from other locations in the Arctic. Central in this substantial effort, is the development of: 1) A climate monitoring network with automated weather stations along with measurements of snowpack properties, 2) module stations with manual and automated monitoring of a variety of state variables linked to the 6 monitoring modules (arctic fox, goose, reindeer, ptarmigan, vegetation and climate), and 3) new methods and technology to study abundance and spatial responses of the tundra ecosystem to changes in abiotic and biotic drivers. Here we present some examples of our hierarchical monitoring design, based on ongoing and planned research, of ecologically relevant state variables in the Svalbard terrestrial ecosystem. We give examples of state-variables and their trophic and non-trophic links and interactions across monitoring modules and ecosystems, to demonstrate the COAT-approach to ecosystem-based ecological monitoring. We present a status and the direction of the current and future work that can form a basis for future integration of ecological monitoring in Svalbard.

## **5211 A century of recovery from overharvest in a warming high Arctic: the successful conservation story of the endemic Svalbard reindeer**

**Mathilde Le Moullec\*, Åshild Ønvik Pedersen, Audun Stien, Jørgen Rosvold, Brage Bremset Hansen\***

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Caribou and reindeer (*Rangifer tarandus*) have experienced recent severe population declines, often attributed to anthropogenic stressors such as harvesting, landscape fragmentation and climate change. The wild reindeer subspecies *R. tarandus platyrhynchus*, endemic to the high-arctic Svalbard archipelago was protected in 1925, after most subpopulations had been eradicated by hunting. While direct pressure from hunting has ceased, indirect anthropogenic stressors from environmental changes have increased in this climate change ‘hot-spot’. An assessment of the current distribution and abundance is urgently needed. We combine distance sampling (300 km transects,  $n = 493$  reindeer groups) and total counts (1350 km<sup>2</sup>,  $n = 1349$  groups) on foot to estimate the Svalbard reindeer distribution and abundance across its entire range, which we compared with historical data from the literature and radiocarbon-dated bones. Reindeer have now recolonised nearly all non-glaciated land (i.e. areas occupied prior to human presence), with spatial variation in abundance tracking vegetation productivity. However, independent of vegetation productivity, recently recolonised areas show lower reindeer densities than areas not subject to past extinction. This suggests that recovery from past overharvesting is still in progress. Because of such ongoing recolonisation, combined with ‘greening’ effects of warming, our status estimate of reindeer abundance is more than twice the previous estimate based on opportunistic counts. Thus, while our study demonstrates the successful outcome of strict harvesting controls implemented a century ago, current and future population trajectories are likely shaped by another anthropogenic impact, i.e. climate change.

## **5212 The greener the better: Predicting habitat suitability in a high-Arctic predator-free large herbivore**

**Åshild Ønvik Pedersen\*, Eeva M. Soininen, Leif Egil Loe, Brage B. Hansen, Steve Albon, Erik Ropstad, Justin Irvine, Audun Stien, Isabell Eischeid, Arnaud Tarroux, Mathilde Le Moullec, Ingrid M. G. Paulsen, Virve Ravolainen**

Norwegian Polar Institute

Quantifying animal spatial distribution at various ecological scales is fundamental to conservation, management and effective monitoring of species. In the high-Arctic tundra, the seasonal variability of forage resources vary dramatically and hence habitat suitability for resident herbivores. Here, we use positional data of an endemic keystone-ungulate, the Svalbard reindeer, which inhabits a simple high-Arctic ecosystem virtually free of determinants of habitat use – competitors, predators and insects – to quantify summer and winter habitat suitability at two ecological relevant scales (forage patch and home range). We used a large dataset of GPS-marked female reindeer (2009-2017;  $N = 268$  females) together with digital data layers on environmental characteristics (terrain and vegetation) and the ensemble forecast modelling framework of the *Biomod2* R-package. We found that the proxy for plant productivity, Normalized Difference Vegetation Index (NDVI), was the most influential predictor of habitat suitability in both seasons, but that terrain variables (elevation,

ruggedness and slope) were more important in winter than in summer to predict habitat suitability. When modelling with coarse vegetation classes, such as moss tundra and heath, which represent the most important foraging habitats, model validation statistics improved. The results support the notion that the Svalbard reindeer females can live a sedentary lifestyle due to proximity to suitable habitats across all seasons. Our study provides the first Svalbard archipelago wide model for habitat suitability across seasons and give a foundation for assessing potential future changes in habitat suitability. It also highlights the need for development of high quality spatial vegetation data layers that can match the high-resolution GPS movement data to quantify the quality and quantity of the seasonal foodscapes of the Svalbard reindeer. As an example of application to conservation and management, we demonstrate the use of the habitat suitability map to identify spatial overlap and “hot-spots” habitat of Arctic resident herbivores.

## **5214 The detailed seismic monitoring of Svalbard and adjacent areas**

**Andrey Fedorov\*, Vladimir Asming**

Kola branch of Geophysical Survey of Russian Academy of Sciences, director, leading scientist

The Svalbard archipelago and adjacent areas are seismically active. Main tectonic earthquakes associated with the spreading of the seabed occur on the Knipovich and Gakkel Ridges located west and north of the archipelago. Tectonic intraplate earthquakes are routinely observed in the archipelago. The glacier destruction processes also generate seismic events called icequakes. Currently, 7 seismic stations (including one seismic array) permanently work on Svalbard. They belong to seismological institutes of Norway, Russia, and Poland.

The Kola Branch of the Geophysical Survey of the Russian Academy of Sciences has been involved in seismic monitoring on the Svalbard archipelago since 1982. Since 2016 a software system for automatic detection and location of seismic events NSDL, developed in the Kola Branch, is used for processing data of most of the stations, which thus form a so-called ‘virtual network’. The NSDL system is based on intelligent data processing algorithms that enable detect and locate even weak seismic events reliably. Thus, in 2018 the system has detected more than 36,000 seismic events with magnitudes from -0.6 to 5.4.

When processing events, the system generates traces that reflect average behavior of signals in the amplitude and frequency domains. Such traces are easy to compare. The procedure of seismic event clustering i.e., grouping of events with similar traces has been developed and applied to the data. As a result, 4 major clusters were obtained. The first one includes tectonic events, the second contains icequakes, and the third involves tectonic earthquakes with epicenters situated along the ridges. The fourth cluster includes several hundreds of events grouped locally at the mouth of Isfjorden and on the coast of Heer land. The records of events of the cluster are characterized by atypically large part of high frequencies in their spectral content.

## **5215 Environmental characteristics of a tundra river system in Svalbard - bacterial abundance, community structure and nutrient levels**

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The bacterial composition in the Arctic freshwaters is linked to the transport of microorganisms from other habitats. The changing sources of water supply affect also the pathways of transporting chemical compounds into the catchment. Although the riverine nutrient concentrations in the Arctic, in inorganic form, are relatively low, such catchments usually discharge high amounts of organic matter and the microbial communities harboured by these watercourses may be very diverse.

The study was conducted on an aquatic ecosystem of the Revelva catchment, based on samples collected in the summer of 2016. The landscape variety of the study site and the seasonal change in the hydrological regime modify the availability of nutrients. The upper part of the catchment consists of mountain rocky slopes which are especially abundant in iron minerals, sulphides and phosphorus minerals. The lower part of the catchment is covered by plants, which are a different source of nutrients. Nutrient limitation can influence not only elemental ratios in biomass, but also cell volume and shape of bacteria. Phosphorus has been found a common limiting element in the Arctic lakes and ponds, although its enhancing effect on bacterial abundance and production is usually only seen in sites with an increased temperature.

The main objective of the conducted research was to observe the biogeochemical diversity of the studied environment with respect to seasonal change. Furthermore, we investigate whether the nutrients present in the studied catchment are sufficient and available for the development of the bacteria living in it, by studying the interactions between the nutrients, such as phosphate, nitrate, ammonia, or organic carbon, and the bacterial abundance.

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## **5216 Joint Norwegian-Russian studies of chemical characteristics in the Templefjorden, Svalbard in 2011-2017**

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Svalbard itself performs a natural Arctic laboratory. Considering climate changes occurring in the Arctic region nowadays Svalbard can be used as a scientific ground for studying processes related to the whole Arctic. Thawing glaciers and permafrost, increasing runoff and mean annual air



temperatures, sea-ice decrease and other accompanying processes are very important for understanding climate change consequences. Thus it is crucial to conduct studies on Svalbard as for local as for regional tasks.

Joint Norwegian-Russian projects (CARSIC and POMPA), supported by Norwegian Research Council (projects 227151 and 246752 respectively) were focused on investigations of the biogeochemical properties of the Templefjorden under changing climatic conditions. The main feature of the Templefjorden is the calving glacier Tunabreen that has been rapidly thawing and for the recent years has lost more than 4 km of its marine part. We have conducted 5 field campaigns (2-7 days) in February 2011, September 2011, March 2014, June 2015 and June 2017. Measured parameters: CTD, all main nutrients (phosphorus, nitrogen, and silica), dissolved oxygen, pH and alkalinity, DOC, Hg in the water (from the fjord and from the stream Murdochhelva), bottom sediments, snow and ice.

The data obtained allowed us to investigate seasonal variability of the Templefjorden water structure. The general results of the investigation have revealed freshening of the very surface layer (3-5 meters) in both winter and summer period. It has caused consequences in mixing process of the water column, saturation with oxygen and nutrients, and carbonate system changes. Such an effect on the Templefjorden ecosystem could change living communities thus the ecosystem itself. Moreover, closed with the glacier part of the bottom of the fjord is now open and it can be revealed features of sedimentation process and flux of matter in bottom-water layer.

## **5217 The demography of polar bears in Svalbard**

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In Svalbard, there are two distinct ecotypes of polar bears. The bears belong to the Barents Sea population. Local bears stay in Svalbard year round. Pelagic bears migrate between Svalbard and the ice edge or the western Russian islands of Franz Josef Land. Norwegian sealers and hunters took about an annual average 300 polar bears over a century ending in 1973, when bears became protected. Based on assumed population intrinsic growth rate, the population should have counted more than 8000 to sustain the hunting. However, it was supposed to be much lower when protected. It likely increased significantly over the next decades. In August 2004, a Barents Sea survey estimated the population size to appr. 2650 (CI 1900-3600) bears. About 250 of these were likely local Svalbard bears. In August 2015, under a survey in the Norwegian part of the area, the number of local Svalbard bears was very similar. The same survey indicated that number of pelagic bears may have continued to increase, and that a decline in the whole Barents Sea population was unlikely to have happened.

Sea ice habitat loss in the Barents Sea area has been dramatic in later decades. Our data indicate that a declining carrying capacity still may be higher than an increasing polar bear population size, this due to the substantial population reduction until bears were protected.

Monitoring data on condition and reproduction does not indicate that habitat loss has profound effects on population level demography. However, traditional good denning areas are lost, and increased distances between islands and sea ice hunting areas demand long costly swims not earlier

needed. Although polar bears in the area cope well with current conditions, future further habitat loss may lead to a sudden decline in condition and reproduction, and a population decline.

## **5218 Seasonal and long-term changes of sea ice conditions in the svalbard and frantz joseph land during XX-XXI centuries**

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The analysis of the sea ice condition by satellite data and ground true observations in the waters surrounding Svalbard and Frantz Joseph Land archipelagos (Fram Strait area, Whalers Bay, adjacent areas of Barents, Greenland, Norwegian and Kara Seas and Arctic Basin) and inside of fiords are provided on a basis of Russian and Norwegian data collected in the Arctic and Antarctic Research Institute (Saint-Petersburg) and Norwegian Meteorological Institute (Oslo and Trømse). Sea ice data is based on an archive of AARI’s historic ice charts from 1950 to present, MET Norway ice charts from 1969 to present, and EUMETSAT OSI SAF sea-ice concentrations climate data record based on satellite passive microwave data covering 1979 to present. Sea ice extent, seasonal changes and long-term variability are investigated. Linear trends of the sea ice characteristics during the last 40 to 60 years are quantified. Comparable description of instrumental and visual sea ice (land-fast ice) and snow data and meta data for Barentsburg, Pyramiden (Svalbard) and “Bukta Tikhaya” (Gukker Island), “Krenkel Observatory” (Hayes Island) at Frantz Joseph Land are presented.

## **5219 Aerosol Optical depth measurements at Ny- Ålesund, Norway**

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Aerosol optical depth (AOD) measurements have been performed within the frame of Global Atmospheric Watch Precision filter radiometer (GAW-PFR) network in Ny Ålesund since 2002. Instrument calibration and protocols follow the ones defined by the World optical depth research and calibration center (WORCC). AOD retrievals are based on direct sun solar irradiance measurements and are available yearly from March till October. In addition, the growing interest of night time observation of AOD led to the development of the Lunar Precision Filter Radiometer at PMOD/WRC. The instrument has been in operation since 2014, monitoring the AOD during the polar winter at Ny Ålesund, while its performance has been validated within the first multi-instrument nocturnal aerosol optical depth intercomparison campaign, (Izaña Observatory, Tenerife, Spain). The LunarPFR is performing measurements during the arctic winter within the framework of the projects: “The Lunar Arctic project” (March 2014 - June 2015) funded by the Svalbard Science Foundation, and “Svalbard Integrated Arctic Earth Observing System Infrastructure - Development of the Norwegian

node (SIOS-InfraNor)” (2018-2027) as well as the extended activities of WORCC. AOD results of night time (November to March) and daytime (April to October) are presented.

## **5220 Monitoring of pollutants in the natural environment of the island of Western Spitsbergen**

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The results of environmental monitoring of environmental pollution of the island of West Spitsbergen, the largest of the islands of the Svalbard archipelago, are presented. Studies are conducted in the areas of the settlements of Barentsburg and Pyramid, the Grumant mine and on adjacent terrariums, as well as in the waters of the Grenfjord and Billefjord bays. In the course of the study, the levels of persistent organic pollutants and heavy metals in the components of the environment (atmospheric air, snow cover, surface and sea waters, bottom sediments, soil, land vegetation) were determined.

The works have been carried out since 2002 by the North-West Branch of the Research and Production Association «Typhoon» (RPA Typhoon) of the Federal Service for Hydrometeorology and Environmental Monitoring of the Russian Federation (Roshydromet). During the observation period, a large databank on the content of pollutants in the components of the environment has been accumulated, which makes it possible to obtain an objective assessment of the state of the surveyed territory, as well as to trace the interannual trend of its change.

## **5221 Long-range transport of biomass burning aerosols in summer’2017 over Svalbard**

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In summer’2017 a large number of intense wildfires occurred in Canada and Greenland, then biomass burning (BB) particles, driven by winds were observed over the Svalbard region. In particular, a very strong BB episode was detected between 18 and 24 August’2017. In that period, an ensemble of aerosol instruments was employed for measurements in Svalbard: a) ground-based in-situ measurements at the Gruvebadet station in Ny-Ålesund base; b) columnar integrated values of AErosol RObotic NETwork in Ny-Ålesund and Hornsund sites and also data obtained on board of r/v Oceania; and c) vertically resolved profiles by a Koldeway Aerosol Raman Lidar (KARL) in the Atmosphere Observatory of the German Base in Ny-Ålesund. The columnar Aerosol Optical Depths (AOD) for August 2017 show very high values at stations located close to or in Canada. Similarly,

increased values of AODs were then observed in Svalbard, with instantaneous values up to 0.5 during 20-22 August at Hornsund (southern site) and Ny-Ålesund (northern site). That event was therefore, a regional episode in the entire archipelago. The in-situ observations showed several significant peaks that period associated with absorbing aerosols. Nitrates and oxalates recorded in Gruvebadet, exhibit a peak in the 21-24 August 2017 period in all the size fractions and in bulk PM<sub>10</sub>, indicating the impact of particles of biomass burning origin. The summer 2017 plume of aerosols, smoke and trace gases, generated over Canada, can be ranked as one of the biggest atmosphere related environmental problems over Svalbard region in last 10 years.

## **5223 Arctic precipitation: Observed trends and changes at Ny-Ålesund, Svalbard**

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Liquid and solid precipitation are important climatic variables in the Arctic that are expected to have undergone significant changes in the past and will undergo further changes due to the changing climate. However, only a few in situ data sets of these variables are currently available in the Arctic. Due to the long history of monitoring activities Ny-Alesund, Svalbard offers the possibility to generate a quality-controlled data set that may serve as a reference of precipitation for the analysis of the impact of a changing climate on the hydrological cycle, on cryospheric processes, on atmospheric chemistry, or on the properties of the soil. However, it is well known that standard gauges to measure precipitation can strongly be biased especially in the case of solid precipitation. We will present our results concerning corrected observed precipitation data in Ny-Alesund for the period from 1975 to 2018. These corrections modified the recorded data, while reducing at the same time the overall uncertainty. Temporal trends in the annual accumulation remain the same for the observed and corrected time series with an overall increase in precipitation in the most recent period. However, the magnitude of the increase is larger in the corrected time series. We will present further analysis regarding the modification of the precipitation phase during the observational period.

## **5224 Snow monitoring at Ny-Ålesund: First results on overwinter snowpack biogeochemical evolution**

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The role of the snow pack in linking bio-geochemical cycles to climate has been largely neglected although it may have considerable significance. In particular, physical, chemical, and biological processes in snow have major impacts on a number of atmospheric and bio-geochemical cycles as well as on cryospheric and terrestrial compartments. For example, the first step in understanding the role of biotic and abiotic inputs on ecosystem functioning in Arctic terrestrial ecosystems is determining the sources of these inputs, how they vary seasonally and how they interact. While

extensive field campaigns have been carried out in the past decades to study these parameters individually, there are only limited efforts that contain the necessary multidisciplinary approach to substantially advance our knowledge in this emerging area. To address these issues coordinated and year-round snow sampling in Ny-Ålesund was initiated based on an international effort and supported by different scientific stations. The goal is to perform long-term observations of basic snow physics and chemistry parameters as well as the impurity and microbiological content of the snow pack.

Here, we will present preliminary results obtained from the first year round sampling beginning in November 2018. Based on collected data, we assess the role of the atmosphere as a source of microorganisms, nutrients and contaminants to the cryosphere and the terrestrial ecosystems (snow, supraglacial environments, and soils), determine seasonal changes in nutrient and contaminant budgets and identify key organisms involved in regulating biogeochemical cycling of nutrients and contaminants.

## **5225 Inter-annual changes of the Atlantic Waters inflow to the Isfjorden in 2001-2018**

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The most important factor of the Isfjorden hydrographic conditions is the inflow of the Atlantic waters (AtW). In this regard, monitoring the intensity of inflow and identifying the processes determining it are among the main tasks of oceanographic research in Svalbard. We used a set of hydrographic data obtained during the expeditions of Murmansk Marine Biological Institute (MMBI) in 2001-2018. CTD-profiling in this period carried out on board R/V "Dalnie Zelentsy" using SEACAT SBE 19 and 19plus.

Using the Golden Software Surfer program we draw temperature and salinity transects along the central axis of the Isfjorden in the direction of Billefjorden. As a criterion of AtW advection we taken the range of propagation in the direction of Billefjorden, the area and the average temperature in the layer bounded by the isohaline 34.8 psu.

Our studies have shown that the maximum AtW advection was observed in July and November of 2017, and the minimum - in August 2003. The maximum of AtW inflow to Isfjorden in 2017 did not prevent active ice formation in the winter of 2018, which is most likely explained by the strong desalination of the surface layer during this period. Analysis of additional hydrographic data from other sources will allow to form a more holistic picture of the variability of the AtW inflow to the Isfjorden over the past 15-20 years.

## **5226 The Bayelva High Arctic permafrost long term observation site: an opportunity for joint international research on permafrost, atmosphere, ecology and snow**

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At present, the Arctic climate is changing much more rapidly than the rest of the globe, and yet the observational data density in the region is low. Permafrost is an important element of the terrestrial Cryosphere, which is strongly affected by changes in Arctic energy and water cycle. There is an urgent need to realistically incorporate permafrost in global modelling frameworks, such as Earth System Models. Evaluating and parameterising these process-based models especially requires simultaneous measurements of interacting variables.

Here we present an example of such a long-term data set, from the Bayelva site at Ny-Ålesund, Svalbard, where meteorology, energy balance components and subsurface observations have been made for the last 20 years.

Since the data provide observations of temporally variable parameters that mitigate energy fluxes between permafrost and atmosphere, such as snow depth and soil moisture content, they are suitable for use in integrating, calibrating and testing permafrost simulations at a range of scale

The data show that mean annual, summer and winter soil temperature data from shallow to deeper depths have been warming over the period of record, indicating the degradation of permafrost at this site. The air temperature in Ny-Ålesund has increased over the past 20 years by about 1.46°C (+/- 0.05°C) per decade. The active layer has doubled in thickness from 0.9 m in 1998 to more than 1.5m in 2018. The freezing period starts later now compared to 20 years ago, leading to a shortening of the period where the soil is frozen of 31 days per decade.

We present examples how the Bayelva data sets is employed to improve global models. Applications not only comprise Earth System Models, but also new high-resolution data sets on the permafrost thermal state compiled in the ongoing CCI Permafrost project by the European Space Agency.

## **5227 The MonArc project: long-term monitoring programme for buildings in Svalbard**

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SINTEF Community; Lomonosov Moscow State University; The University Centre in Svalbard (UNIS)

Monitoring of Arctic Infrastructure project (MonArc, 2017–2019) created and facilitated cooperation between Norwegian and Russian researches based on joined monitoring of buildings in Svalbard. The project is supported by the POLARPROG programme from the Research Council of Norway. Survey of several buildings in small towns of Longyearbyen, Barentsburg, Pyramiden, and Svea was performed in 2017–2019. Ground conditions in Spitsbergen are characterized by continuous permafrost. It is expected that the climate change impact will cause changes in the thickness of active layer and permafrost temperatures in Svalbard in 21st century. There is a concern that changes in permafrost will affect infrastructure stability in Svalbard, where significant climate warming occurs. Performed survey included annual measurement of vertical foundation settlements, characterization of various

damages, observations of the drainage conditions on the sites. The project produced a baseline data set on elevations of foundations as of today. Established data set may serve as a baseline data sets for future comparative studies. Such studies may include detailed assessment of foundation behaviour in changing climate. Combined with long time data series of air and ground temperatures survey may provide valuable information on settlement rate of various buildings and foundations, useful for decision making for maintenance of existing structures and selection of foundation materials and design for future constructions. In this perspective, the MonArc monitored buildings and field sites around them may be considered as a full-scale climate laboratory.

## **5228 Temporal trends of emerging organic contaminants in the Arctic driven by climate change and human activities**

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Emerging organic contaminants (EOCs) may reach ecologically sensitive Arctic environment via atmospheric and/or oceanic long-range transport, while the legacy persistent organic pollutants (POPs) show declining levels. In the past decades, the milder climate and temporal retraction of sea ice, has led the Arctic ocean more accessible and open for various human activities, such as increased shipping, fishing, industrialization, and tourist expedition. These human activities may directly discharge the emerging contaminants in the Arctic as well. Besides, climate change may also affect the contaminants fate in the environment, and cause remobilization among different phases and increasing levels in the biotic environment. As a part of collaborative German-French program at joint French-German Arctic Research Base (AWIPEV) in Ny-Alesund, Svalbard, this project is focused on investigation of the occurrence and long term trends of EOCs in Arctic environment, e.g. air, water and snow, and evaluation air-water and air-snow exchange fluxes.

EOCs including poly- and perfluoro alkyl substances (PFASs), brominated flame-retardants (BFRs) and organophosphate esters (OPEs) have been determined in all air, seawater and snow samples From 2013 to 2018. Data achieved from this study may improve models to predict the environmental progression, assess the effect of human activities and climate change on remobilization, and phase exchange for EOCs in the Arctic ecosystem.

## **5229 The Kongsfjord Ecosystem in a pan-Arctic perspective – Research priorities of the Kongsfjorden System Flagship Program**

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Due to its location right at the interface of Arctic and Atlantic systems, Kongsfjorden and the Ny Ålesund area are crucial sites for the detection of environmental changes, and its ecosystems are considered early warning indicators of upcoming changes extrapolated to a pan-Arctic perspective.

Long-term research and monitoring activities, coupled with multidisciplinary knowledge on Kongsfjorden and adjacent systems, are great strengths that are currently lacking elsewhere in the Arctic. However, understanding the potential of acclimation and adaptation to mitigate changes and maintain critical ecosystem functions remains scattered.

Under the umbrella of The Ny Ålesund Science Managers Committee (NySMAC), the Kongsfjord Flagship Program aims to integrate and coordinate research activities with respect to the structure, function and dynamics of the Kongsfjord ecosystem. Through long-term ecological studies, perturbation experiments and modelling, responses to environmental changes will be elucidated to predict the future conditions of Arctic fjords as well as oceanic areas that are directly linked to open fjords. Future research must be multidisciplinary, encompassing climate, physics, chemistry and responses of the biota. The approach must be integrative, including key polar and boreal species, populations, and communities to facilitate solid predictions on changes in ecosystem services.

Here we provide an overview on the research priorities of the Kongsfjorden System Flagship program, which are organised within seven interdisciplinary work groups: (I.) Physical, chemical and ecological observations, (II.) Contaminant flow and deposition, (III.) Land-sea-atmosphere interactions, (IV.) Seasonal control of the nutrient regime, (V.) Response to key environmental drivers and potential for acclimation and adaptation, (VI.) Approaches in modelling the Kongsfjorden/Krossfjorden ecosystem, (VII.) Kongsfjorden Top Trophics

## **5230 On Distribution of Total Mercury in the Arctic Seas in September-October 2018**

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During the 73d cruise of RV “Akademik Mstislav Keldysh” in September- October 2018 there was studied distribution of total mercury (TotHg) in the surface layer and in the water column. Samples for determination of TotHg in the surface water were taken along the Northern Sea Route streaming from Arkhangelsk (White Sea) to Tiksi (Laptev Sea), and from the water column in the Laptev Sea. Water samples for Hg species analysis were collected in 250 mL fluorinated polyethylene (FLPE) bottles [Braaten et al., 2014] from 5-l Niskin bottles of a complex Rosette for the water column and from a bucket for the surface water.

Measured concentrations of TotHg in the surface water changed in the limits from 2 to 33 ng/l. Baseline concentrations varied from 2 to 8 ng/l. Increased concentrations were found near mouths of the rivers Ob’ (33 ng/l), Northern Dvina (9 ng/l) and near Cape Kanin Nos (15 ng/l). Vertical distribution of Hg measured above a methane seep region was uniform with the concentrations varying from 2 to 8 ng/l without a clear tendency of changes with depth or any correlation with the distributions of methane. An increase of concentrations in the rivers N.Dvina and Ob’ might be explained by anthropogenic influence, but this must be confirmed in the future studies.



## **5231 Ringed seal (*Pusa hispida*) demography in a time of habitat change**

**Magnus Andersen\***, Kit M. Kovacs, Christian Lydersen

Norsk Polarinstitutt

Ringed seals have evolved in close association with Arctic sea ice and depend on it for most aspects of their life history. Sea ice has declined markedly in the Svalbard Archipelago over the last three decades, but little data is available on the effects of these changes on ringed seal demography. This study compares harvest data on body size, age structure and reproductive rates from three periods spread over the last four decades (A: 1981-1984 (n=277), B: 2002-2004 (n=272) and C: 2012-2018 (n=213)) to study potential changes in these parameters. Body length showed no clear pattern over the three study periods; males were longer in period C while females were longer in period A compared to the other periods. Animals in time periods A and B were collected March-May, while period C also had animals collected June-October, precluding direct comparisons of body mass and condition (which vary markedly seasonally) for the whole sample in each period. A subset including only May data suggests that body condition did not vary between the three periods. Age distributions for A, B and C were similar, with the exception that period C had a higher proportion of animals in the 0-3 yr age group. Age at sexual maturity for males and females was similar for periods B and C, both being lower than in A. Ovulation rates did not vary among the three periods, being 0.87, 0.86 and 0.91 for C, B and A, respectively. Pregnancy rate was only available for period C (0.79). Although ringed seals in Svalbard have experienced significant change to their habitat over the last 30 years, demographic parameters appear to be largely unaffected to date. More research on the reproduction, survival, density and population size are needed before firm conclusions can be drawn regarding the status of this population.

## **5232 Fractional snow cover over the last decade at Ny-Ålesund**

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The availability of the fractional snow cover area over a long time period is an important dataset useful for remote sensing and climate applications. Terrestrial photography offers reliable information about the snow cover with a limited effort in terms of resources and it reduces problems created, for example, by the cloud cover as occurs with the satellite imagery. This study presents the support provided by terrestrial photography for the estimation of the fractional snow cover at Ny-Ålesund using panoramic images taken for twenty years and analyzed using an automated snow-no-snow detection algorithm based on spectral similarity. The available cameras are located at the Zeppelin Observatory (475 m a.s.l.) and at the Climate-Change Tower (60 m a.s.l.). While the first camera provides different views over the Kongfjorden since 2000, the second one has started to operate in 2018 looking at the Brøggerbreen glaciers. The analysis is based on two components: the orthorectification of different views; and the estimation of the snowed area. The analysis includes also the quality check of the final estimations that is approached controlling the stability of the camera view geometry, the data corruption and the presence of visibility biases (mist, snowfall and rainfall). Each camera provided information in different geomorphological domains (coastal plain, glacier front, mountains) and specific masks were prepared for each perspective view. The preliminary results are presented in terms of time-series concerning the presence of snow cover area with particular attention to the melting seasons.

## **5233 The impact of human activity on the state of the environment: monitoring in Barentsburg and its surrounding territories**

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Human activities in varying degrees affect the state of the environment. In some cases this effect can be quite negative. In this regard the availability of reliable information on the state of the environment allows us to identify negative trends and promptly eliminate or at least minimize the influence of sources that form such trends.

Here, in Barentsburg, the coal mine and the power plant are the main sources of environmental contaminants, such as heavy metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, etc. In this study we are trying to identify specific sources of pollution in the settlement of Barentsburg and evaluate their influence at the surrounding areas.

## **5234 Long-term temperature trends and the recent warming between Svalbard and Franz Josef Land**

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The Arctic has warmed dramatically in recent decades, with greatest temperature increases between Svalbard and Franz Josef Land along the 80th parallel north, according to reanalysis data. However, scarcity of validation data hampers the confidence of the reanalysis data in this region. In this contribution, we compile and analyze a large number of unpublished surface air temperature data from meteorological land stations in eastern and northern Svalbard and Franz Josef Land. Some of these series have not previously been analyzed. The main objective is to establish consistent datasets and study the recent warming and long-term trends in northern parts of the Barents Sea, from Svalbard to Franz Josef Land. Particularly interesting is the recent warming pattern and how this is related to variations in large-scale atmospheric circulation and the decline of sea ice.

Specifically, we address the following three research questions: Are the temperature trends in the north-eastern area of the Barents Sea area more pronounced than e.g. at western Svalbard? How much of the temperature trends in the study area is related to the reduced ice cover? How do the temperature trends (based directly on station data) correspond to trends in reanalysis data?

The study is based on Russian-Norwegian collaboration (AARI/SPbSU-MET Norway). The new joint dataset on air temperature is denser, and the time series are longer than those used by the scientific community so far. The quality of the temperature series has further improved by using modern homogenization methods and by extensive use of metadata from the archives. Climate data from Russian weather stations on Franz Josef Land are made available for the entire period 1928-present. MET Norway has made available automatic weather observations from the 1990 to present from

Norwegian weather stations north and east on Svalbard. From western Svalbard a composite series from 1898 already exist.

## **5236 Using drone based imagery to study climate, herbivore and vegetation interactions in the Arctic tundra**

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Climate change has profound effects on the arctic tundra and its herbivores. In Svalbard, drivers of change include higher ambient temperatures, changes in snow properties, icing events, snowmelt patterns and the onset of greening. Multiple drivers such as slow changing trends or major disturbance events can change the state of the arctic tundra ecosystem. Most of these landscape-changing processes occur frequently but at low spatial scales; this requires monitoring techniques that capture ecologically relevant details at varying spatial scales. The rise of satellite and unmanned aerial vehicle (UAV) technologies has opened up new doors to monitor landscapes in remote locations such as Svalbard. The advantage of UAVs is that they can cover relatively large areas of several hectares at high resolution and can be useful link between field based data and satellite images. In COAT – Climate-ecological Observatory for Arctic Tundra we are working to develop photogrammetry-based methods to advance our capability of monitoring state changes in arctic tundra ecosystems. This will be achieved by combining drone imagery, field measurements and satellite images to better understand how multiple disturbances (e.g. herbivores and permafrost thaw) together shape heterogeneous landscapes. The frequent disturbances such as goose grubbing and icing, and an increasing need to monitor their effects, call for development of vegetation maps of selected tundra types that includes indicators of disturbance and change. With advancements in vegetation and snow classification, as well as animal detection from UAV images, we further hope to develop tools to better quantify herbivore abundances and disturbances across Svalbard's tundra throughout different seasons.

## **5237 Circumpolar status of arctic ptarmigan: Population dynamics and trends, a CBMP initiative**

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Rock- (*Lagopus muta*) and willow ptarmigan (*L. lagopus*) – are arctic birds with a circumpolar distribution. However, there is limited knowledge about their status and trends across their circumpolar distribution. Ptarmigan species are herbivorous birds of large ecological and societal importance in alpine and arctic ecosystems. They are important game species and most places characterized by multiannual density cycles. Although studies from different regions have pointed out how climate change likely affect future population dynamics and distribution of ptarmigan, we lack a good understanding of how ongoing and predicted climate change processes will affect ptarmigan populations, particularly in the Arctic. Therefore, the Terrestrial Ecosystem Working Group of the Circumpolar Biodiversity Monitoring Program (CBMP) selected ptarmigan as a focal ecosystem

component (FEC). We have compiled information from 90 ptarmigan study sites from 7 Arctic countries, where almost half of the sites are still monitored. Rock ptarmigan showed an overall negative trend on Iceland and Greenland, while Svalbard and Newfoundland had positive trends, and no significant trends in Alaska. For willow ptarmigan, there was a negative trend in mid-Sweden and eastern Russia, while northern Fennoscandia, North America and Newfoundland had no significant trends. Both species displayed some periods with population cycles (short 3-6-y and long 9-12-y), but cyclicity changed through time for both species. We propose that simple, cost-efficient systematic surveys that capture the main feature of ptarmigan population dynamics can form the basis for citizen science efforts in order to fill knowledge gaps for the many regions that lack systematic ptarmigan monitoring programs.

### **5238 Recolonization and succession of a sub-tidal hard-bottom benthic community in Smeerenburgfjorden, NW Svalbard**

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Rapid changes to the physical environment of Arctic marine systems in recent years impact the structure and function of benthic ecosystems. Understanding the resilience of these systems to perturbations requires a solid understanding of key ecological processes and must be conducted over decadal time scales due to the natural variability of biological systems, and slow growth and recruitment of many Arctic benthic organisms. This study addresses the successional pattern of a hard-bottom benthic community on a vertical rock wall at 15 meters depth in Smeerenburgfjorden (NW Svalbard) and the functional traits involved in the different stages of recolonization after clearing the substrate in 1980. Analysis of biannually photographed surfaces showed different return rates among taxa and fluctuating abundance (solitary taxa) and cover (colonial invertebrates and macroalgae) throughout the time series. The results found species-specific recolonization patterns, abrupt shifts in community structure and function, and a slow recovery rate following the disturbance, thereby suggesting Arctic coastal ecosystems to be both potentially vulnerable to human impact and difficult to make predictions for.

### **5239 Plant diversity and species richness responses to climate warming in Ny-Ålesund, Svalbard**

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The Arctic is a sensitive region for global climate change, and growing evidence shows this region is undergoing rapid warming, which will pronouncedly influence the Arctic ecosystem and biodiversity. Currently both experimental warming and long-term monitoring researches have been performed at sites across the Arctic to investigate the vegetation changes in community composition and

phenology, but studies reporting responses of diversity were scarce. Ny-Ålesund is located on the west coast of Svalbard and meteorological data document that this area is experiencing a significant warming in recent decades. Here we present the consequences of climate warming for plant diversity and species richness based on a long-term observation (2011-2019) in Ny-Ålesund. Our data show that species number remains decreasing over time in most plots or no significant change in few plots. Margalef index indicates species richness experiences increasing or decreasing over time in response to warming. Simpson and Shannon-Wiener indexes suggest diversity response to warming over time is more complex, including increasing, decreasing, or increasing and decreasing alternately. The trends in diversity and richness need to be tested by a longer observation in the future. This study provides valuable data for terrestrial ecosystem response to climate warming in the Arctic.

**Keywords:** Arctic; diversity; long term monitoring; Ny-Ålesund; plot; species richness; Svalbard; vegetation change

## **5240 How can a field laboratory for research and teaching contribute to long-time monitoring?**

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Academic institutions are under constant pressure to streamline operations and reduce costs. Researchers and teachers must therefore cooperate more closely to be able to take advantage of the time and resources we invest in fieldwork in a good way, so that both the research benefits for the employees and the learning outcomes for the students are best possible.

To meet these challenges, the Arctic Biology (AB) Department at UNIS has established a common, cross-disciplinary field-laboratory in Bjørndalen, Svalbard. This location can be reached year-around from UNIS, and all staff members have research interests in the area. Based on the needs within ongoing research projects, we have invested in measurement stations for obtaining a variety of biotic and abiotic parameters. Data are obtained in a gradient from the open sea, through the coastal zone and onto land.

Such a field laboratory will create a cost-effective research synergy between employees, authentic research experiences for the students, and form the basis for initiating new projects with national and international partners who can contribute with further instrumentation and data capture. All data retrieved from the field laboratory, either through student courses or research projects, are made available in a common database. In this way we can easily initiate small research projects, like inquiry-based student projects, that piece by piece increase the overall knowledge of the study system. We can embrace the interaction in the ecosystem as a whole, and over time separate seasonal and mid-year variations from more lasting climate change.

Thus, good coordination of research projects, student course work and data sharing will lead to long-time monitoring. All data collected, small and large, will eventually be made available for the public through, for example, [SIOS \(Svalbard Integrated Arctic Earth Observing System\)](#).

## **5241 The monitoring of Kongsfjorden enhanced by lasers – what have we learned after first 5 years of research**

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Institute of Oceanology Polish Academy of Science

Kongsfjorden has long been known as a good marine observatory of the climate-related changes in Svalbard archipelago. In turn plankton has been recognized as one of the best elements to reflect the progressing ecosystem modifications and 'Atlantification'. However the long-term monitoring, based on traditional taxonomic analyses, is time consuming and spatially limited to only a few stations. Therefore we started to supplement our standard monitoring of protists and zooplankton by the high-resolution measurements of the two laser particle/plankton counters (LISST for 1-120 $\mu$ m and LOPC for 0.1 – 35mm size fractions). During 5 years we studied changes in relative roles of various plankton taxonomic groups collected by nets and bottles together with high-resolution mapping of particular size fractions derived from laser counters along the 100-km transect (starting from the innermost glacial bay and ending at the shelf edge). Our approach is to integrate the wide size range of particles and plankton (from pico- to macro-) over time and space to present an innovative and broad picture of plankton ecosystem components and the complexity of energy transfer through primary and secondary producers. Moreover, through crossing different zones (glacial bay, fjord main basin, fjord entrance and shelf) we could compare them in a comprehensive way and to map the spatial range of the plankton related to the advection of Atlantic water as well as of the particles discharged with the glacial meltwaters. In the coming years we are going to seek for the future perspectives to the more automatic mode of monitoring and consequently to advance our investigation by other sensors (optical measurements of turbidity, underwater camera for macrozooplankton and marine aggregates) in order to better describe the contribution of various living and non-living water components and to predict the effect of those on feeding possibilities for visual vs. tactile predators.

## **5242 Long-term decline of spring AOD in Ny-Ålesund**

**Christoph Ritter\***

Alfred Wegener Institut, Potsdam

The Alfred Wegener Institute performs long-term aerosol measurements of the aerosol optical depths (AOD) since 1991 by sun- and star-photometers. In this work we show a decrease of spring AOD over the years, meaning that the Arctic Haze phenomenon, at least in the atmospheric column, decreases. Trends for the summer are not so pronounced. Therefore, in the future, the AOD may almost evenly distributed throughout the year.

Secondly, from the year-to-year variability in the Arctic haze and by trajectory analysis we have a hint that high sea ice cover correlates with more AOD. Hence the sea ice decline may have shortened the aerosol life-time. Typical pollution pathways will be discussed.

Finally, Mie code calculations are used to estimate the information content behind photometer data. A new approach beside the well known Angström law is introduced. We found indications that during spring in the Arctic Haze season, the aerosol seems to be more homogeneous and its size in

the atmospheric column may roughly correspond to the size distribution found by in-situ measurements. Contrary, in summer the aerosol may be more heterogeneous and hence the ground-based data may not be representative for the whole atmosphere.

## **5243 What does Svalbard driftwood tell us about recent sea ice dynamics?**

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Over 100 naturally-felled driftwood specimens were collected from modern beach settings along a N-S transect in Northern Svalbard. They were taxonomically identified to genus via micro-anatomy and dated and provenanced through dendrochronology (tree-ring width) and  $^{87}\text{Sr}/^{86}\text{Sr}$ . Since this material arrived to Svalbard in the recent past (most of it landed within the last 200 years), it constitutes a recent record of long-distance, sea ice-transported driftage than can in a large part be directly compared to independent existing sea ice observations and sea ice reanalysis products.

Our study tested the following hypotheses:

**(1)** Driftwood delivery in Svalbard has decreased in the recent past due to a drop in multiyear sea ice.

**(2)** Driftwood provenance correlates in time with the position of the Transpolar Drift.

**(3)**  $^{87}\text{Sr}/^{86}\text{Sr}$  can serve as a reliable provenance technique that overcomes the temporal limitations of dendrochronological approaches.

**(1)**, **(2)**, and **(3)** test whether **a)** driftwood is a reliable long-term proxy for sea ice dynamics that can be used to extend sea ice reconstructions at high spatial and temporal resolutions during the Holocene; and **b)** the decline in multiyear sea ice around Svalbard in the recent decades can be quantified in a reduction in driftwood delivery, which has consequences to the long-term transport and delivery of organic material entrained in sea ice from continental landmasses around the pan-Arctic basin, such as plant propagules.

## **5245 Interplay between atmosphere, sea ice, and oceanic heat transport over the continental slope north of Svalbard**

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The Arctic sea ice cover is shrinking, both Arctic-wide and in the European Arctic. North of Svalbard, the ice edge retreated north and eastwards over the recent decade compared to earlier years, but large interannual variability persists, driven by atmospheric and oceanic processes. Since 2012, a mooring array has been monitoring the Atlantic Water inflow – the largest oceanic heat source for the Arctic Ocean – along the continental shelf break north of Svalbard. We present analysis of the first five years of hydrographic and current observations and corresponding developments in the regional sea ice cover. In some years, large oceanic heat flux events in autumn and early winter prevent local ice formation and melt sea ice that is advected into the region. Atmospheric drivers, in particular wind-driven vertical mixing and sea ice advection, also play a major role for presence of

sea ice over the upper continental slope north of Svalbard and the longevity of the ice pack into the summer season.

## **5246 Spatial Distributions of Black Carbon and Mineral Dust in Air and Snow Surface Layers upon Svalbard Glaciers: the BC-3D project (a Svalbard Strategic Grant) final report**

**David Cappelletti\* (1), Chiara Petroselli (1), Beatrice Moroni (1), Jean Charles Gallet (2), Stephen Hudson (2), Elisabeth Isaksson (2), Bartłomiej Luks (3), Adam Nawrot (3), Marion Maturilli (4), Christoph Ritter (4), Roland Neuber (4), Mauro Mazzola (5), Angelo Viola (5), Elena Barbaro (5), Andrea Spolaor (5), Catherine Larose (6)**

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Black carbon (BC) and mineral dust (MD), when deposited on snow and glaciers, can have substantial effects on the radiative balance of the Arctic. The reflectivity of snow surface (albedo), a dominant parameter affecting the energy balance in Polar Regions, depends on the snow grain size, wetness, and impurities in the near-surface snow layer. Estimation of snow albedo is essential for predicting seasonal snow developments, for determining glacier mass budgets and for calculating the regional and global energy budgets.

This topic has attracted substantial attention recently, in part due to the fact that about 50% of BC sources impacting the Arctic are located in northern Europe and Russia and MD sources (e.g., due to volcanic eruptions or lifting by wind) are also often located in northern high latitudes. The influence of the latter is still underestimated and expected to increase due to the enlargement of deglaciated areas in the Northern hemisphere.

The scientific goals of the project have been to evaluate the distribution of BC and MD in the first layers of atmosphere and surface snow over targeted Svalbard glaciers in order to identify the mechanisms of the air/snow exchanges and the possible role of katabatic winds in distributing the pollutants along the glacier valleys.

Consistent results have been obtained in the Ny-Ålesund area (2016, 2017, 2018, 2019) and in the (very different) Hornsund area (2019) allowing to generate a comparative study in multiple sites.

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## **5247 Recent Trends in Extreme Precipitation over Svalbard**

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In the last decade, several extreme precipitation events over Svalbard have been observed, which all had a strong impact on the environment and society. It is well known that those events are connected to atmospheric rivers, which bring warm and moist air towards higher latitudes. Only very few historical observational records exist for precipitation on Svalbard, and thus it is not possible to understand recent changes in the extreme precipitation characteristics over Svalbard from observations only. We developed a novel approach to determine recent (1980 to 2018) trends in extreme weather from a large high-resolution ensemble hindcast. The hindcast is from a seasonal prediction system, and constrained to atmospheric and oceanic reanalysis data. With this large ensemble, the confidence intervals are greatly reduced, which allows us to study precipitation events with very long return periods of several 1000 years, as well as, to identify trends in precipitation. We analysed trends of 2- to 200-year return values over Svalbard and find for all levels a significant trend of 10 to 20% within the last 35 years. The largest trends are found in the northern parts of Svalbard. We will further illustrate how this approach can be utilized to deepen our physical understanding of the processes driving change in precipitation extremes over Svalbard.

## **5248 High Arctic ecosystem states: Conceptualizing vegetation change for long-term monitoring and research**

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Vegetation change has consequences for ecosystem structure and functioning and may interfere with climate feedbacks. Hence, when monitoring ecosystem states and changes thereof, the vegetation is often a primary monitoring target. Here, we summarize current understanding of vegetation change in the high Arctic –the World’s most rapidly warming region – in the context of ecosystem monitoring. To foster development of deployable monitoring strategies, we categorise different kinds of drivers (disturbances or stresses) of vegetation change either as pulse (i.e. drivers that occur as sudden and short events, though their effects may be long lasting) or press (i.e. drivers where change in conditions remains in place for a prolonged period, or slowly increases in pressure). To account for the great heterogeneity in vegetation responses to climate change and other drivers we stress the need for ecosystem specific conceptual models to guide monitoring and ecological studies. We conceptualise three alternative vegetation states characterized by mosses, herbaceous plants and bare ground patches, respectively, and use moss-graminoid tundra of Svalbard as a case study to discuss the documented and potential impacts of different drivers on transitions between those states. Our current understanding points to likely additive effects of herbivores and a warming climate, driving this ecosystem from the moss-dominated state with cool soils, shallow active layer and slow nutrient cycling to an ecosystem with warmer soil, deeper permafrost thaw and faster nutrient cycling. The herbaceous-dominated vegetation and the (patchy) bare ground would be two

common states in such a changed system. Conceptual models are an operational tool to focus monitoring efforts towards management needs and identify the most pressing scientific questions. A priori defined expectations of the focal systems' responses to different drivers also facilitates linking local and regional monitoring efforts to international systems such as the Circumpolar Biodiversity Monitoring Program.

## **5249 Contaminants of emerging Arctic concern (CEAC) as indicators for local contamination in the Arctic**

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During the past decade, the development and application of new, highly sensitive trace analytical instruments and methods have resulted in the identification of a large number of organic contaminants of emerging concern (CEC) in Arctic environments. The recently published Arctic Monitoring and Assessment Programme (AMAP) assessment on CECs is a comprehensive testimony of the wide array of contaminants currently investigated in the Arctic environment. During the past decade, the list of priority CECs considered as relevant for Arctic pollution assessment was expanded into new flame retardants (i.e. organophosphorous flame retardants (OPFRs)), personal care products (e.g. synthetic musks and cyclic siloxanes), pharmaceuticals, surfactants, food stabilising chemicals and many more. Moreover, the AMAP assessment on CECs in the Arctic revealed a surprising complexity of sources, distribution processes and transformation pathways of these contaminants. By collating existing research and monitoring results, the assessment contributed to a new scientific understanding of the sources and environmental fate of anthropogenic contaminants in the Arctic environment. As a consequence, AMAP has recently expanded and reorganised the future assessment strategies based upon these extended new findings. Future investigations of sources to Arctic pollution will include a stronger focus on local sources in addition to long-range transport. Our presentation will illustrate the application of new research results in regional screening and monitoring activities with several relevant examples including Svalbard. Focus will be laid upon recent study on local sources for perfluorinated alkylated substances (PFAS and polycyclic aromatic hydrocarbons (PAHs) and their transformation products. Implications and consequences for local pollution control and regulations will be discussed.

## **5250 Long-term Monitoring of the Carbon Cycle in Adventdalen, Svalbard** **Frans-Jan W. Parmentier\* (1,2), Lennart Nilsen (3), Philipp R. Semenchuk (4), Torben R. Christensen (5), Norbert Pirk (1), Mikhail Mastepanov (5), Hans Tømmervik, Elisabeth J. Cooper (3)**

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Svalbard is the fastest warming place on the planet, which has major consequences for snow cover, vegetation productivity, permafrost stability and the interactions among these factors. It remains unclear, however, how the carbon cycle will be affected by these changes. Thicker snow packs, for example, insulate the ground from the coldest winter temperatures, effectively warming the soil. This deepens active layers, causes surface subsidence, and modifies pathways of permafrost carbon loss. However, our understanding of the effect of snow cover on the mobilization of carbon from permafrost soils is severely limited. Moreover, it is unclear how the exchange of greenhouse gases from ecosystems compare in magnitude to lateral losses into the aquatic domain. In this presentation, I will focus on two long-term monitoring experiments in Adventdalen on Svalbard. One snow fence experiment, started in 2006, and an eddy covariance tower that was installed in 2011. The snow fence experiment showed that thicker snow cover not only causes permafrost degradation through warming, but also extensive erosion and mobilization of sediment due to increased surface drainage and runoff. These two processes amplified each other and triggered a dramatic change in the landscape. Within six years, the mere presence of a 6 m long snow fence led to the collapse of a 50 m long ice wedge network, forming a deep gully in the landscape. We estimate that lateral carbon losses were roughly 60 to 275 times larger per unit area than the vertical exchange measured by the nearby flux tower. This presentation highlights the importance of long-term monitoring to study arctic change and that surface hydrology can be an important driver of permafrost carbon loss. This aspect should be considered in future monitoring experiments and projections of the permafrost carbon feedback.

## **5251 Sentinel-1 InSAR for mapping ground displacements in Svalbard** **Tom Rune Lauknes\* (1), Line Rouyet (1,2,3), Yngvar Larsen (1), Hanne H. Christiansen (3), John F. Dehls (4), Dag Anders Moldestad (5)**

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Svalbard is characterized as a high latitude, high relief periglacial landscape. In the lowlands, the uppermost part of the ground above the permafrost, called the active layer, thaws in summer and refreezes in winter. This can induce cm-scale subsidence and heave due to the phase change of the water-ice present into the ground. On valley sides, various mass-wasting processes induce downslope ground displacements. The displacement rate varies spatially and temporally depending on environmental factors and indirectly documents the dynamics of the ground thermal regime. In

addition, these displacements are important to take into account for the management of infrastructure and for the assessment of geohazards.

Although ground dynamics in Svalbard has practical implications and is important to document in a context of climate change, measurements of displacements in Svalbard are currently mainly based on in-situ instrumentation and provide sparse and unevenly distributed information. The development of satellite remote sensing can be used to scale up the mapping of ground displacements using Synthetic Aperture Radar Interferometry (InSAR) techniques.

In previous projects, we showed that InSAR can be valuable to:

- Identify fast moving areas around Longyeardalen that can potentially affected infrastructure or safety of population;
- Document the timing of the ground freeze and thaw, as a correspondence between seasonal subsidence/heave patterns and ground temperature has been evidenced;
- Monitor the changes of kinematics on creeping landforms (e.g. rock glaciers), as landform acceleration in a context of climate change has been evidenced.

The launch of the European Commission Copernicus Sentinel-1 SAR satellites has opened up new opportunities for monitoring of surface movement using InSAR. The recent release of the “InSAR Norway” ground motion service (<https://insar.ngu.no>) has been widely acknowledged as a valuable tool to identify unstable areas. In this presentation, we discuss the potential to develop a similar initiative in Svalbard.

## **5252 Long-term data set (2007 to 2017) of eddy covariance CO<sub>2</sub> and energy fluxes at High Arctic Bayelva site, Svalbard**

**Katharina Jentzsch\*, Alexander Schulz, Johannes Lüers, Julia Boike**

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The Arctic is warming at an unprecedented pace. Within the last 25 years an increase of near-surface air temperature exceeding the global warming by a factor of two has been observed.

One effect of this amplified warming is the thawing of permafrost and associated changes in surface gas and energy fluxes. Increasing permafrost greenhouse gas emission might even trigger further warming, resulting in a positive feedback loop. This highlights the need to reasonably estimate future greenhouse gas emissions and uptake by permafrost regions.

This can only be achieved by incorporating permafrost dynamics into global modelling efforts.

Currently there is a large spread between outputs of different Earth System Models.

Since model results are useless without information about their uncertainty, in situ measurements of surface carbon fluxes are invaluable for their evaluation.

Furthermore they allow an access to an urgently needed deeper understanding of the microscale gas exchange processes taking place.

However in the Arctic region there are still very few measurement sites providing long time series of observational data.

Here we present one of these few long-term data sets, recorded by an eddy-covariance tower at the Bayelva site close to Ny-Ålesund, Svalbard.

The comparatively warm permafrost site is characterized by the influence of the North Atlantic current leading to a maritime climate with average temperatures of 5 °C in July, relatively high winter temperatures of –13 °C in January and an annual mean temperature of -2.5 °C.

About 400 mm of precipitation are observed per year and the snow free period amounts to typically three months.

Carbon dioxide concentration, humidity, wind velocity, temperature and snow depth have been measured at the station from 2007 to 2017. Therefrom we derived half-hourly net ecosystem exchange of CO<sub>2</sub> as well as sensible and latent heat fluxes using the eddy covariance software TK3.

## **5253 Long-term observations of rivers in the Grønfjorden area**

**Kseniia Romashova\***, Igor Vasilevich, Mikhail Tretiakov

Arctic and Antarctic Research Institute

The current global climate changes affect all elements of the Arctic environment. In order to assess correctly the effects of changes and their magnitude, it is necessary to conduct long-term observations of the most sensitive elements, such as the Arctic rivers.

AARI hydrology team have been conducting hydrological monitoring since 2001. The most complex observations have been carried out since 2017. At the surface water bodies of the Grønfjorden basin located in the vicinity of the Russian settlement Barentsburg. Specifically, they are the rivers Grøndalselva, Grønfjorddalselva, Bretjørna, Aldegonda, Brydebekken, Kongresselva. Discharge observations annually cover the whole period from the breaking up of the ice to freezing up.

The highest annual flow of 45-55 million m<sup>3</sup> is observed at Bretjørna river while its total sediment load to the fjord is relatively small and estimated up to 400 tons per year. The Grøndalselva river makes the highest input of sediments to the fjord about 20 thousand tons per year. However, its annual flow does not exceed 40 million m<sup>3</sup> of fresh water. The annual flow of the other Grønfjorden basin rivers is less than the annual flow of each Bretjørna and Grøndalselva and totals 40%.

The total annual flow to Grønfjorden is estimated on average of 150 million m<sup>3</sup> and 47 thousand tons of sediment in recent years. Main ions runoff (Ca<sup>2+</sup>, Mg<sup>2+</sup>, K<sup>+</sup>, Na<sup>+</sup>, HCO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>) to Grønfjorden is about 33 thousand tons per season. Sulfate and hydrocarbon ions make up 70% of the total mass.

## **5254 Ny Ålesund Atmospheric Flagship Program**

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The Ny-Ålesund Research Station in Svalbard, Norway, is located on the West coast of Spitsbergen at 79°N. The combination of unique location and modern infrastructure makes Ny-Ålesund the ideal location for research and environmental monitoring related to environmental changes in the Arctic. The Ny-Ålesund Science Managers Committee (NySMAC) works to enhance cooperation and coordination between institutions and includes representatives from all parties with major interests in Ny-Ålesund. The research in Ny-Ålesund is coordinated through four flagship programs:

Atmosphere, Marine System, Terrestrial Ecosystem and Glaciology. The main goal of the Atmosphere Flagship is to coordinate the atmospheric research and related activities conducted by several institutes from more than ten countries in Ny-Ålesund. It provides meeting places for scientific discussions and collaboration, arenas for the coordination of field-activities, and platforms for increased information flow between the individual research groups. The atmospheric flagship unites the related research through eight work packages. These include work related to aerosols, clouds, atmospheric composition, meteorology, interactions between atmosphere and cryosphere and long-term trends. It spans from the mixing layer close to the ground up to the upper atmosphere. At Svalbard Science Conference we will highlight the collaborative nature and major scientific goals of the Atmospheric Flagship Program.

## **5255 Gridded hydrological projections for Svalbard**

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The assessment report Climate in Svalbard 2100 describes historical and projected changes in Svalbard's hydrology, among other topics. In general, increased rainfall will lead to increased flood magnitudes. Methodological issues pose a challenge to i) quantifying the Increase as well as to ii) producing gridded hydrological variables for Svalbard. First, limited access to observations make up a major challenge for climate projections at Svalbard. No more than 15 temperature stations, nine precipitation stations, and two runoff stations are available for an area of  $\approx 60\,000\text{ km}^2$  (corresponding to one third of South Norway). Second, a mismatch between low-resolution Arctic-CORDEX data (50x50 km) and the downscaled products (1x1 km) represent another substantial challenge. Here, we describe how bias-corrected and downscaled temperature and precipitation data from an ensemble of Arctic-CORDEX projections data were used to force the hydrological model HBV with the aim to produce gridded runoff and other hydrological variables. More data gathering and research on downscaling methods is required for such gridded projections to be relevant for impact studies on Svalbard.

Keywords: Svalbard, downscaling, bias-correction, temperature, precipitation, hydrological variables

## **5256 Traditional perceptions of Isfjorden plankton enhanced by optical approach**

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Isfjorden is the largest Spitsbergen fjord, which paradoxically is still one of the worst described areas of European Arctic in terms of pelagic communities, despite the fact that many different plankton focused projects/programs operate there. Contrary to the majority of previous Svalbard plankton studies concentrated on traditionally comprehended, separately investigated phytoplankton and mesozooplankton, in this study we assessed wide plankton size fractions. Our investigations were conducted by using the innovative and conventional methods in four consecutive summers (2013-2016) along 60 km transect crossing waters of strong environmental gradient. Starting from Billefjorden – the deepest, innermost part of Isfjorden, bounded with glacier branches, freshened by meltwaters highly loaded with suspended mineral particles, through central part up to Adventfjorden

strongly influenced by Atlantic water inflow. The water samples for chlorophyll a concentrations, nano- and microplanktonic protists taxonomic composition and abundance were taken by Niskin bottles while samples for mesozooplankton enumeration and taxonomy were collected with plankton nets at 3 stations located along the transect of automatic optical measurements. Full particle-size structure (between 1  $\mu\text{m}$  to 10 mm) was measured in Isfjorden in combination of Laser In-Situ Scattering, Transmissometry (LISST-100x) and Laser Optical Plankton Counter (LOPC) and obtained data demonstrated generally good agreement. Application of combined methods allowed for the integration of optical instrument-derived data with those obtained with classical microscopy techniques. Additionally, the simultaneous investigation of vertical distribution of different plankton size fractions allowed us to argue about their relative roles in various layers of Isfjorden pelagial. Different environmental conditions faced during our survey, with rapid melting and increased Atlantic water inflow enable us to improve the overall knowledge on the possible effects of various hydrographical scenarios on restructuring of different plankton size assemblages in this high Arctic fjord.

## **5258 Variability of snow cover characteristics in the Grønfjorden basin**

**Igor Vasilevich\*, Kseniia Romashova, Mikhail Tretiakov**

Arctic and Antarctic Research Institute

Snow covers the major part of Svalbard from mid-autumn to early summer. Snow cover features prominently in modern changing climate research due to its sensitivity to these changes. In turn snow accumulation and melting pattern influences rivers and lake regime.

Since 2001 AARI hydrology group has been conducting snow cover research in Grønfjorden area. The observation program includes measurements of height and density of snow cover and its structure description during the period of maximum snow accumulation from mid-March to late April. The areas of annual work were expanded in 2015 to the watersheds of the Grøndalselva, Grønfjorddalselva, Brydebekken, Kongresselva, East and West Grønfjord glaciers, as well as the Aldegonda glacier - directly on the glacier and on its moraine.

The observed interannual variability of snow cover characteristics over the last years turned out to be insignificant. Thus, the depth of the snow cover for the period of observations from 2002 to 2019 in the Grønfjorddalen varied from 21 cm to 92 cm with STD of 21 cm ( $C_v = 0.36$ ), while the water equivalent of snow cover varied from 131 mm to 526 mm with STD of 95 mm ( $C_v = 0.35$ ). Snow cover characteristics depends directly on precipitation amount and temperature conditions during the winter period, which result from the development and interaction of large-scale pressure formations. These interactions are partially characterized by oscillation indexes. Our estimation shows no statistically significant relationship between the snow cover characteristics and the North Atlantic Oscillation index. However, there is a correlation between the Arctic Oscillation index and the height and moisture content of snow cover in the Grønfjorddalen, the highest correlation coefficient (0.5) characterize its seasonal part, specifically the average AO index for January, February and March.

## **5259 Towards sharing 20-years long catalogs of glacial seismicity in Svalbard for interdisciplinary usage**

**Wojciech Gajek\* (1), Andreas Köhler (2)**

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Glaciers are one of the key elements affected by the Arctic climatic system which are being studied by scientists from numerous fields.

Still, various measurements for glaciers monitoring are limited by difficult access and low temporal resolution.

Glacier-induced seismicity is directly influenced by both seasonal glacier cycle and long-term behavior affected by the changing climate.

Continuous, high quality seismograms from seismological stations located just next to Svalbard's glaciers provide an opportunity to trace the dynamic behavior of nearby ice bodies for almost 20 years back.

Moreover, these seismic stations gather continuous data in superb temporal resolution, while being almost fully autonomous.

Nevertheless, routine usage of the seismic data for glacier monitoring is still limited. Pilot studies in Svalbard have shown that seismic records can be utilized for numerous purposes such as estimation of frontal ablation and calving rates as well as studying water discharge and surge detection.

We believe, that a key for a successful incorporation of seismological observations into interdisciplinary research lies in finding a sharable format for these results being usable by glaciologists or other non-seismologists.

Therefore, we have developed tools for automatic processing of long-term seismic records that produce open access catalogs of seismic events, and provide ready-to-use statistics of glacier-induced seismicity occurring in the vicinity of permanent seismological stations in Svalbard.

We e priorities accessibility and applicability of seismological glacier characteristics for scientists with no particular experience in the field of seismology in order to facilitate their ongoing research through data integration.

Our study demonstrates the possibility of using long-term seismological observations from single permanent stations to automatically monitor the dynamic activity of nearby glaciers and retrieve its characteristic features.

## **5260 Seismological monitoring of Svalbard's cryosphere: status and future directions - a contribution to the SIOS SESS report 2019**

**Michal Chamarczuk (1), Wojciech Gajek (1), Wolfram Geissler (2), Andreas Köhler\* (3), Mariusz Majdanski (1), Michal Malinowski (1), Johannes Schweitzer (3), Andreas Wuestefeld (3), Christopher Nuth (4)**

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We provide a review of the current state and future potential of cryoseismological research in Svalbard which is a rapidly developing frontier research area in Earth Sciences. Recent studies showed that the existing seismic monitoring infrastructure in Svalbard can be used to map and study



the spatio-temporal distribution of glacier-induced seismic events, benefiting from long observation periods (>20 years). For example, seismic observations calibrated with satellite and terrestrial remote-sensing calving observations allow estimating continuous glacier frontal ablation rates at Kronebreen with unprecedented high temporal resolution, helping to better understand processes at the ice-ocean interface. Furthermore, passive seismic data have been used to study en- and subglacial processes such as crevassing, glacier speed-ups, and meltwater discharge. Cryogenic seismic signals have also been utilized to constrain the timing and to better understand glacier surges in Svalbard. Time-lapse monitoring of the subsurface using ambient seismic noise has been applied for monitoring seasonal permafrost active layer variability or to study the internal structure of glaciers. Passive, non-invasive cryoseismological methods have therefore a huge potential to complement established methods for monitoring the cryosphere in Svalbard. We highlight future directions of cryoseismological research which will for example benefit from new seismic deployments, new developments in instrumentation (fibre-optic cables), and automatic techniques for seismic event detection employing machine learning. We suggest using the existing and new seismic data volumes to extend seismic glacier monitoring (calving and surging) to regions so far unstudied in Svalbard. Furthermore, future interdisciplinary research should focus on calibrating seismic monitoring techniques based on ambient seismic noise to physical parameters related for example to glacial meltwater discharge or changes in the permafrost active layer. Moreover, we believe many geophysical methods that are being used in glacier and snow studies such as ground-penetrating radar and active seismic can be complemented by passive seismic measurements.

## **5261 Discovery of the Fastest Ice Flow along the Central Flow Line of Austre Lovénbreen, a Poly-thermal Valley Glacier in Svalbard**

**Songtao Ai\*, Jiachun An, Zemin Wang**

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Ice flow velocity is a sensitive indicator of glacier variations both controlling and representing the delivery of ice and affecting the future stability of ice masses in a warming climate. Austre Lovénbreen (AL) is one of the poly-thermal glaciers in the high Arctic and located on the northwestern coast of Spitsbergen, Svalbard. The ice flow velocity of AL was investigated using in situ global positioning system (GPS) observations over 14 years and numerical modelling with Elmer/Ice. First, the ice flow velocity field of AL along central flow line was presented. While AL moves slowly at a speed of approximate 4 m/a, obvious seasonal changes of ice flow velocity can be found in the middle of the glacier, where the velocity in spring-summer is 47% larger than in autumn-winter in 2016, and the mean annual velocity variation in different seasons is 14% from 2009 until 2016. Second, the numerical simulation was performed considering the poly-thermal character of the glacier, and indicated that there are two peak ice flow regions on the glacier, and not just one peak ice flow region as previously believed. The new peak ice flow zone found by simulation was verified by field work, which also demonstrated that the velocity of the newly identified zone is 8% faster than the previously identified zone. Third, although our field observations showed that the ice flow velocity is slowly increasing recently, the maximum ice flow velocity will soon begin to decrease gradually in the long term according to glacier evolution modelling of AL.

## **5301 Marine littering in the Barents area: fishers' attitude**

**Julia Olsen\* (1), Bjørn Vidar Vangelsten (1), Anne Katrine Normann (2), Leticia Nogueira (1), Ingrid Bay-Larsen (1)**

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In the Barents area, fisheries contribute a high portion of the marine litter that threatens marine life, and ultimately the provision of clean and healthy seafood. Little knowledge is accumulated on causes and solutions related to marine waste from fisheries. There is also a lack of systematic data on what influences the fishers' attitude to waste management, on their access to facilities for disposal of waste produced onboard as well as litter collected while fishing, and on their perception of challenges and solutions to the marine litter problem. By applying a value approach and mix methods methodology, this study aims to explore fishers' attitude and practices to handle marine waste.

The empirical data derives from 19 qualitative interviews and 197 responses from a survey among fishers from Northern Norway. The data indicate that attitudes have changed during the last years, partly because of the recent focus in the media. There has been a gradual shift in attitude, where fishers realize that the ocean no longer is a convenient dumping place, and that litter is harming the environment.

The study concludes that fostering fishers' awareness and providing them with knowledge of adequate waste management practices, as well as adequate infrastructure is effective in influencing their attitude and practices concerning the problem of marine litter. Port authorities also have an important role: easy-to-use and reasonably priced waste facilities in harbors are key to encourage proper waste management onboard, as well as bringing to shore litter collected in the ocean. Standardization of waste management facilities in harbors will increase efficiency of waste management and reduce the time fishers use for waste delivery.

The project group of this study cooperates with several Research Institute and Fishers Unions to address this emerging topic. Still, pan-Arctic cooperation can be beneficial to share best practices and solutions.

## **5302 Polymer composition of ingested plastics by Arctic northern fulmars (*Fulmarus glacialis*)**

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Marine plastic pollution affects a myriad of species across the world. Seabirds, and especially Procellariiformes, have been identified as particularly vulnerable to ingesting plastics. The ingestion of plastics by the northern fulmar (*Fulmarus glacialis*) has been studied for many years across its distribution range as part of monitoring efforts investigating the status of plastic pollution in the ocean. However, there is a lack of knowledge regarding the polymer composition of the ingested plastics, which is important for the development of meaningful mitigation strategies. The aim of this study was therefore to assess the degree of plastic ingestion and particularly the polymer composition of ingested plastics by northern fulmars from Svalbard and north-east Greenland using Fourier-transform infrared spectroscopy. A total of 267 plastic pieces ingested by two northern fulmars caught in Svalbard (2013) and 176 plastic pieces ingested by 31 northern fulmars caught in

north-east Greenland (2017) were examined, piece by piece. The results show that the majority of fulmars from both regions had ingested plastics. There were no significant differences in the mean mass of ingested plastics between the fulmars from Svalbard and north-east Greenland. The ingested plastics from both regions were predominantly composed of polyethylene, followed by polypropylene and polystyrene. There was a significant difference in the polymer profile between the two regions; northern fulmars from Svalbard had ingested a larger proportion of polystyrene plastics compared to the northern fulmars from Greenland, which had ingested more polypropylene plastics. This study is among the first investigating the polymer identity of ingested plastics and—in addition to contributing to the understanding of local marine plastic pollution—will provide a valuable comparison once similar studies have been conducted in other regions of the Arctic.

### **5303 Ingested plastics in northern fulmars (*Fulmarus glacialis*): a pathway for polybrominated diphenyl ether (PBDE) and chlorinated paraffin (CP) bioaccumulation?**

**Svenja Neumann\***

Although it has been suggested that plastic may act as vector for pollutants into the tissue of seabirds, the bioaccumulation of harmful contaminants released from ingested plastics, is poorly understood.

Therefore, the present study, analysed polybrominated diphenyl ethers (PBDEs) and chlorinated paraffins (CPs) in the liver of adult northern fulmars (*Fulmarus glacialis*) sampled at two locations in Norway. PBDE and CP concentrations of birds with and without ingested plastics and contaminant concentrations in ingested plastic samples of the same fulmars were quantified.

As a second part of the project, blood samples of juvenile northern fulmars collected on Bear Island, Svalbard were analysed for PBDEs and CPs to assess if blood may serve as a less invasive sampling method for quantifying organic pollutants.

PBDEs were detected in all liver samples at high concentrations with peak values of almost 3000 ng/g lipid weight. PBDE209 was found in all ingested plastic and in all liver samples from birds with ingested plastics. Furthermore, PBDE209 dominated the pattern in some samples and contributed with up to 94% of the total concentration. In the livers of fulmars without ingested plastics, PBDE209 was not detected. Therefore, the results of the present study strongly suggest the transfer of PBDE209 to the tissue of fulmars.

CPs were quantified in all ingested plastic samples, but were only detected sporadically in the liver samples of the same birds. In fulmars without ingested plastics, CPs were not detected. Thus, it is proposed that CPs were eliminated and the results do not suggest a relationship between ingested plastics and CP accumulation.

In the blood of juvenile fulmars, PBDEs were found but PBDE209 and CPs were absent. Thus, the results of the present study indicate that the blood of fulmars may serve as an alternative sampling method to quantify PBDE concentrations.

## **5304 Plastic additives in sediments and biota from Kongsfjorden and Rijpfjorden, Svalbard**

**Maria E. Granberg\* (1), Lisa W. Von Friesen (1), Kerstin Magnusson (1), Geir W. Gabrielsen (2)**

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Due to excessive production and poor waste management during the past 60 years, plastic waste has reached our seas, degrading into micro- and nanoplastics and spreading with currents even to the most remote places. In the Arctic, microplastics are also released to the sea with e.g. untreated wastewater from towns and settlements and from plastic-laden sea ice as it melts in spring. Plastics are made through polymerization of monomers, often containing chemical additives which shape the properties of the plastic. These additives include plasticizers (e.g. phthalates), stabilizers (e.g. bisphenol A), flame retardants (e.g. PBDE), antioxidants (e.g. nonylphenol) and pigments (organo-metal compounds). Plastic-associated chemicals leak from the material during use and as they degrade, thus the marine environment can be exposed through wastewater, runoff, atmospheric deposition and plastic weathering in situ.

We measured concentrations of the following groups of plastic additives/associated chemicals; phthalate esters, organophosphate esters, bisphenols, polybrominated flame retardants (BFR) and phosphoorganic flame retardants (POFR). Contaminants were measured in marine sediments, three benthic invertebrate species with different feeding modes (*Hyas* sp., *Buccinum* sp. and *Serripes groenlandicus*) and in blood and eggs of the Common Eider (*Somateria molissima*) in the Kongsfjord and Rijpfjord, Svalbard.

Preliminary results show that POFR are found at similar and low concentrations in biota at all sampled sites, thus indicating a diffuse and perhaps long-range source of contamination. Concentrations of Bisphenol B and BFR were higher in invertebrates and sediments in the Kongsfjord area close to Ny-Ålesund compared to in Rijpfjord, indicating local pollution sources. Higher concentrations of Bisphenol B, phthalates and BFR were found in the scavenging crab *Hyas* sp., indicating potential biomagnification. In conclusion, plastic additives occur in marine sediments and biota close to human activities. Specific compounds (POFRs) are also found widespread, likely resulting from atmospheric or sea related transport processes.

## **5305 Point sources and accumulation zones of anthropogenic microlitter in Arctic waters: a synthesis of several studies in Svalbard and Greenland**

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An increasing number of studies confirm widespread litter pollution in the Arctic marine environment. The relative importance of local point sources of litter has not previously been studied in greater detail but is essential knowledge for science-based management. Here, a synthesis compiling several of our studies focusing on point sources, accumulation zones and distribution of anthropogenic microparticles (AMPs, < 5 mm, including microplastics) in Svalbard and Greenland, is presented. Measurements of concentration and composition of AMPs have been performed throughout the water column, in sediment, beach sand, sea ice, wastewater and benthic food-chains. Sampling has in several matrices been pursued with varying proximity to known anthropogenic activities to enable a discussion on point sources and subsequent dispersion.

Wastewater treatment is generally lacking in Arctic settlements and is therefore often discharged directly into the sea. Wastewater was indeed identified as a point source of AMPs from Ny-Ålesund on Svalbard. Correspondingly, wastewater discharge in Sisimiut on Greenland contributed with a wide range of AMPs to the coastal marine environment. Sea ice north of Svalbard, although far from land-based human activity, was identified as an accumulation zone and point of release of AMPs upon melting, raising concern around increased bioavailability to the ice edge ecosystem.

There is a tendency to underestimate the impact of local pollution sources in the vast Arctic region. In the wake of climate change, industrial development and tourism is expected to increase. This leads to rapid and temporally varying population increases supported by a highly underprovided municipal infrastructure. A pilot study clearly showed that installation of even small-scale wastewater treatment can efficiently lower the spread of AMPs. The here compiled information forms a part of the important basis needed for appropriate coastal zone management measures for marine litter pollution in the Arctic.

## **5306 Arctic Marine Litter: A circular approach**

**Eelco Leemans\*, Wouter Jan Strietman**

LMC / WUR

### Background

Through ocean currents, a continuous stream of plastic arrives to the Arctic. So far, only the general sources were known. In the Arctic Marine Litter Project, a thorough method was applied, engaging stakeholders to reveal specific sources, underlying causes and possible solutions of beach litter in Jan Mayen and Svalbard.

The aim of the Arctic Marine Litter project is to bridge the existing knowledge gap about the sources of marine plastics in the region and the underlying causes. New knowledge gained during the project will provide input into ongoing activities to reduce marine litter in the Arctic.

### Methodology

First step was collecting and identifying key beach litter items, either on remote beaches, or in waste facilities when litter was collected by other parties. Next step was engaging with industry experts (as fishermen and fishing net manufacturers) and applying detailed beach litter analysis methods. This way we have gained detailed knowledge on the sources and underlying processes and behavior that may have contributed to marine litter in the Arctic.

### Preliminary results

- Most recognizable items are fisheries related
- Some specific findings on fishing nets:
  - None of the analyzed nets were full nets, all were sections of net;
  - Most nets are from either shrimp or cod trawling fleet in the Barents Sea;
  - The type of netting is used as by Russian and Norwegian fishing vessels;
  - Most of the net sections have most likely been discarded at sea after repairs.

### Next steps

- Additional research in remote Arctic areas to complete the picture;
- Engagement with stakeholders (fisheries, local authorities, policy makers, fishing gear manufacturers, ports) in the search for solutions;

- ‘Telling the story’: raise awareness on the issue of marine plastic pollution in the Arctic.

### **5307 Microplastics pollution in the sediments of Kongsfjord**

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Plastic pollution is well recognized as a major threat to the health of our oceans. Fragmentation of larger plastic debris lead to the formation of microplastics (< 5 mm) known as secondary microplastics while primary microplastics are manufactured and commercially available for uses such as the micro-beads in personal care and cosmetic products, or as the pre-production pellets to make common plastic products. Microplastics are reported from numerous marine ecosystems including the deep sea and Arctic waters. Despite of the common belief that Arctic is one of the last pristine environment existing on Earth, this region is also polluted with plastic wastes. Here we present a report on microplastics pollution in Arctic sediments collected from eight sites in Kongsfjord, during Summer of 2017. Analysis of the sediment samples revealed an average abundance of  $1.4 \pm 2.4$  particles / kg sediment. Micro Raman (WITee Alpha 300RA, Germany) spectroscopy analysis has indicated HDPE, LDPE and Polyamide as the polymer components of the microplastics, while HDPE was the predominant polymer identified. Relatively higher number of microplastics particles were observed with site 5 ( $6 \pm 2.8$  particles / kg sediment). Shape of the particles varied from film, fragment and fibers. Particle size ranged between 55  $\mu\text{m}$  and 471  $\mu\text{m}$ . This study, being one among the few reports available on microplastics from Arctic sediment, provide impetus for further research on the distribution and impact of this emerging pollutant in various matrices of Arctic ocean/fjords. Sources and pathways of microplastics in Arctic environment remain unclear, further detailed studies are needed for understanding sources and effects of microplastics on Arctic environment.

### **5309 Plastic pollution contributions by major rivers within the Greater North Sea Region**

**Boglarka Baksay\***

Marine Scotland, University of Stirling

The main hypothesis of this project, carried out as my MSc dissertation research at the University of Stirling, states that the largest influence of individual discharge of the examined rivers has a positive association with plastic loading into the Greater North Sea Region (OSPAR II). The methodology involves comparing methods of estimating macro- and microplastic loading from major European rivers around the sea, while also investigating whether plastic inputs are evidently related to seasonal changes in the area. The dissertation focuses on three principle sources: rivers, direct discharges from wastewater treatment plans, and direct mismanaged litter from urban areas. All rivers within the Greater North Sea Region emit plastics in various size groups from micro- (300 microns to 5mm) to macroplastics (over 5 mm in diameter) from remote sources. These riverine inflows have already been measured or estimated through different methods, with data being stored in various databases of governments and non-governmental organizations, or having been included in previous publications. Furthermore, direct sources of plastic pollution also include contributions coming from land, shipping and onshore installations.

This cooperative dissertation project is part of a broader research program of Marine Scotland which

is aimed at creating a so-called Plastic Budget, a baseline estimate of the flows of plastic through the North Sea, an area of great natural, political and economic importance. The program is ultimately going to inform a box model of ocean fluxes and plastic pollution contributions in the examined region, to be published by Marine Scotland. Such a budget of plastics, and with it, the riverine input research conducted for my dissertation, could provide guidelines for future research, policy-making and marine planning objectives worldwide, including the Arctic Waters (OSPAR I) and Svalbard.

### **5310 Microplastic sample collection onboard a ferrybox equipped MS “Norbjørn” at a transect Tromsø-Longyearbyen in June 2019**

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Samples for determination of microplastic in the surface water were collected along a transect from Tromsø to Longyearbyen in June 2019 during the cruise of MS “Norbjørn”. This vessel is equipped with a ferrybox system allowing continuous measurements of physical and chemical parameters in the water and the air. The filtration system (with 1.5 and 0.2 mm metal filters) was connected to the ship fire system that took water from 3 m depth. Sample size ranged from 6000 to 15000 l collected over a period of 6-10 hours. Quantification of microplastics in the samples were performed in the laboratory using a combination of visual assessment and ATR-FTIR (Attenuated Total Reflection Fourier Transform InfraRed). The collected data will be used for the work on modelling of plastic distributions in the Arctic that were started in the frame of the KLD funded project ESCIMO "Establish regional capacity to measure and model the distribution and input of micro plastics to the Barents Sea from rivers and currents."

### **5311 Studies of Microplastic Distributions in the Arctic Seas in September-October 2018 during the 73 cruise of RV “Akademik Mstislav Keldysh”**

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In the 73d cruise of RV “Akademik Mstislav Keldysh” between September- October 2018 samples for determination of microplastic in the surface water were collected along the Northern Sea Route streaming from Arckhandelsk (White Sea) to Tiksi (Laptev Sea) from a continuous flow system. At least 10000 l collected from 3 m depth were filtered for every sample through 1.5 and 0.2 mm metal filters. Analyses were performed with MicroNIR 1700 ultra-compact spectrometer onboard and following visual investigation and ATR-FTIR (Attenuated Total Reflection Fourier Transform InfraRed) after the cruise. In total, 22 samples of the surface water were collected and with microplastic fragments were detected in 4 samples and fibres detected in 6 samples. In addition, plastic particles were collected from marine sediments along a transect from River Lena delta to the Laptev Sea slope. Marine sediments were collected with a box corer of 0.25 m<sup>2</sup> and approx. 0.0625 m<sup>3</sup> volume. From 8 to 16 fragments/0.25 m<sup>2</sup> were found at stations affected by River Lena discharge, the same stations were characterized by increased organic matter content and decreased oxygen concentrations. FTIR application confirmed presence of plastic material PET (Polyethylene terephthalate, 1.38 g/ml density), probably a degraded plastic bottle. Here we present, new

methodology for collecting and analysing microplastic particles in surface water from a continuous flow system was tested in the cruise. Chemical composition of fragments was examined, that allowed to determine (hypothesise) origin of the plastic in the regions affected by rivers and transport from Atlantic water. The performed work can be used as a new approach/tool towards organising the pan-Arctic monitoring observations. The collected data will be used for the work on modelling of plastic distributions in the Arctic that were started in the frame of the KLD funded project ESCIMO "Establish regional capacity to measure and model the distribution and input of micro plastics to the Barents Sea from rivers and currents."

## **5401 Dust over Svalbard: autochthonous or exotic?**

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Eroded Svalbard mountain ranges are dominant source of dust, which is deposited on and preserved in the local glaciers. The glaciers of Svalbard are also excellent repository for eolian dust, originating from local and external sources. Here we report preliminary results from analyses of dust particulates, collected from shallow (0.5-1m long) firn cores of the Hansbreen, Storbreen, Flatbreen, Recherchebreen and Werenskioldbreen glaciers of southern Spitsbergen. The cores, acquired during the Spring of 2018, were divided into ca. 1.5 kg specimens, which were then melted and filtrated using polycarbonate membranes of 0.45  $\mu\text{m}$  pore size. Using standard mineralogical methods, we identified a range of mineral phases, including pyrite, iron oxides, quartz, K feldspar and rutile. Zircon and monazite were also present, with grains sizes promising for geochronological dating. Coarser grains probably stem from proximal areas, whilst finer grains may have been transported from more distal sources. Particulates composed of elemental carbon have been found in a number of specimens, although their origin is still unknown. An alloy of Ni+Fe composition may be a micrometeorite grain.

Monazite dating using CHIME method revealed their Silurian (syn-Caledonian) ages, suggesting Nordaustlandet region of Svalbard as a potential source of the dust.

Rock-magnetic studies revealed domination of magnetite grains. Interestingly, no hematite has been found, contrary to its abundance in subtropical/moderate climatic zones. This may point to local rather than exotic alimentation sources for dust in the glacier of the Southern Spitsbergen.

Above results indicate the potential to utilize dust mineral compositions for glaciostratigraphy, glaciotectonics, recognition of dust load density distribution, including potential cosmogenic sources or degree of anthropogenic dust contamination over the region. During forthcoming seasons, we are planning to continue these studies over broader areas. With bigger dataset, a correlation of dust fallout with glacier facies or seasonal snowfall/rainfall will also be sought.



## **5403 The frozen archives in a warming climate**

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Svalbard glaciers and ice sheets are well-known archives of past climate and environmental conditions. Over the last two decades, ice cores have been retrieved from three major glacier-ice caps in Svalbard; Lomonosovfonna, Austfonna and Holtedahlfonna. The reconstructed winter surface air temperatures show that the 1800s, was the coldest century in Svalbard going back up to 1200 years, and that there has been recent warming. The ice cores have also provided information of a range of pollutants; including black carbon (BC), polychlorinated biphenyls (PCB), brominated flame retardants (BFRs) and current use pesticides (CUPs). The different geographical positions and characteristic of the coring locations also provide information on both the spatial variability component, in addition to the temporal record. We have also gained new knowledge about the transport of pollutants, and processes during and after deposition on the glaciers. Some of the pollutants show a clear east-west zonal gradient across the archipelago suggesting a different origin for air masses arriving in different sectors of Svalbard. There is also an indication that some of these sites have been affected by local sources of industrial contaminants (PCBs). These glaciers are going through rapid changes with increasing temperatures; the stored contaminants during many decades will eventually be released by melting and affect downstream ecosystems. The concentrations and effects of this still needs to be investigated. It is also urgent to recover ice from these glaciers for future studies before the meltwater percolation affects the stratigraphy making dating no longer possible.

## **5404 GPR survey of the Aldegonda glacier**

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The Aldegondabreen is a small mountain-valley glacier of about 6 km<sup>2</sup> located on the west coast of Gronfjord. From 1936 to 1990, the glacier retreated more than 900 meters and lost 40% of its volume. As a result of detailed ground-based GPR surveys made here in 1999, its two-layer polythermic structure was detected, a map of the thickness was constructed, and the presence of an inglacial channel within the southern, deepest part of the glacier was revealed.

The purpose of the GPR surveys in the years 2018-2019 was to obtain new data of the thickness and structure of the glacier 19 years later, taking into account the emergence of modern GPR equipment and high-precision navigation. GPR observations of 15 profiles with a total length of more than 21 km were carried out within the glacier.

After processing the data, a map of the glacier bed was constructed and the obtained depths were compared at the common measurement points 1999 and 2018-2019. On average, over 19 years, according to GPR measurements, the thickness of the glacier decreased by 19–20 m. In the deep

parts of the glacier, intervals with intense reflections associated with the presence of “warm” ice areas were identified and localized.

Additionally, local anomalies associated with the internal drainage system of the glacier were identified on the sections. In order to localize the selected objects, detailed profiles were performed, which made it possible to delineate an extensive zone of water inflow from the surface and trace the system of channels on most part of the glacier.

## **5405 KOPRI’s Research Program for the Reconstruction of Holocene paleoenvironmental changes in the Arctic Svalbard fjords**

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Starting in 2015, KOPRI launched a five-year research project (July 2015 – June 2020) titled "Research on environmental changes in fjords and coastal geomorphology: Towards a better understanding of the erosion and redeposition processes of the Svalbard archipelago in the Arctic", which is supported by the National Research Foundation of Korea (NRF). The main objectives of this project are 1) the assessment and mapping of coastal geomorphology, 2) the reconstruction of environmental changes caused by the Holocene climate changes in the fjord systems in Svalbard, and 3) the development of paleoenvironmental proxies for Arctic research. The first joint expedition between Korea and Norway with R/V Helmer Hanssen in summer of 2016 provided invaluable data and new sediment cores that kept records of the Holocene and recent environmental changes in various Fjords such as Dicksonfjorden, Isfjorden, Van Mijenfjorden, and Hornsund.

Our effort to unravel the geologic and environmental background of Svalbard extended to the fjords in the northern Svalbard (Wijdefjorden, Woodfjorden) and beyond the summer sea-ice margin in the far north during the second joint cruise between Korea and Norway on the R/V Helmer Hanssen (July 26 – August 1, 2017). This summer, the third joint cruise between Korea and Norway to the Svalbard fjords (Isfjorden, Van Mijenfjorden, Van Keulenfjorden, and Hornsund) will be carried out in order to collect further data on bathymetry and chirp-profiles as well as new sediment cores with R/V Helmer Hanssen (August 2 –7, 2019). The overall goal of the marine-geological research program is the reconstruction of the climate history of the Svalbard fjords through the post-deglaciation.

Bathymetry and chirp data will provide further insights into the evolution of glacial sediments in the Arctic fjord complex systems since the last post-glacial period.

The new sediment cores collected during the three expeditions enable us to study the holistic history of environmental changes in the Svalbard fjords during the Holocene. Based on data obtained, we will continue to analyze the mechanisms of environmental changes such as sediment deposition, sea-ice formation, and retreat from the glaciers in the Svalbard archipelago to study the effects of future climate change in the polar region.

## **5406 Diversity and ecological functions of biological soil crusts in High Arctic ecosystems (Billefjorden, Central Svalbard)**

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The most important biological communities in periglacial terrestrial semi-arid and arid deserts areas in the High Arctic are Biological Soil Crusts (BSCs). Mainly mosses, lichens, fungi, cyanobacteria and eukaryotic microalgae compose them. With climate changes, the BSCs are predicted to facilitate the “greening” of the Arctic, a phenomenon associated with increased biomass coverage by BSCs and the subsequent succession by shrub tundra, responsible for an increase of carbon sink. Microalgae (prokaryotic cyanobacteria and eukaryotic algae) are keystone microbial species of the BSCs, being significant primary producers, fixing atmospheric nitrogen and producing polysaccharides that bind soil aggregates together. In the last few years, we have studied the cyanobacteria and microalgae of BSCs to characterize their diversity and ecological functions (photosynthesis and nitrogen fixation) in Billefjorden, central Svalbard. The diversity of cyanobacteria and microalgae in different stages of development of the BSCs was analysed; a) using morphological (cell biovolume - stereomicroscopy - light microscopy) and molecular methods (NGS amplicon sequencing of cyanobacterial 16S rRNA and eukaryotic 18S rRNA sequences of isolates), b) diurnal courses of photosynthetic and nitrogenase activity and, c) microclimatic and soil chemical conditions. The results showed that cyanobacteria prevailed in most barren soil types, dominated by filamentous cyanobacteria *Leptolyngbya* spp. In contrast, microalgae (green and yellow-green algae) were more abundant in frequently disturbed vegetated soils. Nitrogenase activity decreased from poorly to more developed soil crust types. Temperature was the main factor influencing photosynthetic activity of BSCs soil crusts. Higher temperatures led to inhibition of photosynthetic activity and increased energy dissipation, indicating acclimation of the soil crust photosynthetic microorganisms to cold environment.

## **5407 Influence of glacial water on carbonate chemistry and biogeochemical processes in Svalbard fjords with different characteristics**

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Svalbard fjords on the west-Spitsbergen are influenced by Atlantic water in the outer parts and by glacial water and sea-ice processes in the inner parts. The fjords also have different characteristics depending on the sill depth, seasonal sea-ice coverage, and the presence of tidal glaciers and rivers. Here, we present the distribution and variability of the carbonate chemistry and ocean acidification state in several Svalbard fjords based on data collected at several seasons between 2012 and 2018. For the study, we used total alkalinity (AT), total dissolved inorganic carbon (DIC), pH, dissolved inorganic nutrients, salinity, temperature and calculated calcium carbonate (CaCO<sub>3</sub>) saturation state ( $\Omega$ ), and calculated freshwater fractions to investigate the seasonal and interannual variability and the biogeochemical processes driving the carbonate chemistry, air-sea CO<sub>2</sub> flux and ocean

acidification state in the different fjords. Changes in the inflow of different water masses and freshwater directly influenced ocean acidification state, but also indirectly by affecting the biological drivers of carbonate chemistry in the fjords. The seasonal variability showed the lowest  $\Omega$  and pH values in winters coinciding with the highest freshwater fractions. The highest  $\Omega$  and pH were found in fall, mostly due to CO<sub>2</sub> uptake during primary production.

In the climatically sensitive Kongsfjorden, glacial water decreased  $\Omega$  by the same amount as the biological effect increased  $\Omega$ . The seasonal increase in temperature only played a minor role on the increase of  $\Omega$ . Overall, we found that increased freshwater supply decreased  $\Omega$ , pH and AT. On the other hand, we observed higher AT relative to salinity in the freshwater end-member in mild and rainy winters in Tempelfjorden. Observations of calcite and dolomite crystals in the glacial ice suggested supply of carbonate-rich glacial drainage water to the fjord. This implies that winters with a large amount of glacial drainage water partly provide a lessening of further ocean acidification, which will also affect the air-sea CO<sub>2</sub> exchange.

## **5408 Spread of Svalbard glacier mass loss to Barents Sea margins revealed by CryoSat-2**

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Svalbard is located in the most rapidly warming area of the Arctic, at the interface of Arctic and Atlantic air and ocean masses. This results in steep gradients in temperature and precipitation across the archipelago. A significant proportion of the 34,000 km<sup>2</sup> glacier cover exhibits cyclic dynamic changes known as surging. The potential for rapid changes in climatic mass balance and ice dynamics necessitates regular monitoring through satellite remote sensing.

Here, we present an assessment of 2011-2017 Svalbard mass balance based on CryoSat-2 swath radar altimetry. We estimate 7-year rates of elevation change from least-squares plane fits to individual elevation measurements within km-scale grid cells, and use the elevation residuals to derive time series of change. We find a total Svalbard rate of mass change of  $-16 \pm 2 \text{ Gta}^{-1}$ , of which  $10.4 \text{ Gta}^{-1}$  is from non-surging ice and  $-5.6 \text{ Gta}^{-1}$  from surging ice. This is equivalent to a global SLR contribution of  $0.044 \text{ mma}^{-1}$ . This represents a considerable acceleration in mass loss since the comparable period of ICESat laser altimetry in 2003-2009, and we compare the assessments from the two satellites to study the spatial pattern of this acceleration.

The results demonstrate that the west coast glaciers remain the major contributor to (non-surging) mass loss, but mass loss is also spreading into areas bordering the Barents Sea, including the southeastern coast of Spitsbergen, Olav V Land, Barentsøya and Edgeøya, and southern and eastern margins of Austfonna. Regions of low magnitude mass change are limited to Vestfonna, northern Austfonna, and high elevation portions of northeast Spitsbergen.

We show sea ice decline and lower atmospheric warming have occurred adjacent to the areas experiencing an increased mass loss, and suggest that the 'Atlantification' of the Barents Sea is a likely driver, consistent with a pattern of increasing glacier mass loss across the Eurasian high Arctic.

## **5409 Impact of a shallow tidewater outlet glacier on marine primary production**

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Tidewater outlet glaciers have been recognized to have positive effects on marine primary production in their adjacent fjords. The currently suggested hypothesis explaining the increased phytoplankton production is the entrainment of nutrient-rich bottom water into the upwelling of subglacial meltwater. With climate change tidewater outlet glaciers are retreating which might lead to nutrient limited fjord ecosystems.

Besides the indirect upwelling effect, we hypothesize that direct fertilization by micronutrient inputs, such as iron, fertilizes the adjacent fjord.

Our study site is Billefjorden on Svalbard, a fjord characterized by Arctic conditions with a shallow sill and influenced by the shallow tidewater outlet glacier Nordenskiöldbreen.

We tested our hypotheses by a seasonal study of stratification and freshwater inflow, measurements of biomass, microalgae community structure, and primary production along a transect out from the glacier front.

We detected the signature of winter nutrient upwelling between November and April supplying the fjord with fresh macronutrients fueling the spring bloom. Subglacial meltwater reached the fjord throughout the winter, but its concentrations of macronutrients were lower than in fjord sea water. Nonetheless, primary production and bacterial production were an order of magnitude higher in front of the glacier compared to the middle of the fjord. A water exchange experiment showed that seawater from the front of the glacier has fertilizing effects on phytoplankton communities from the inner and middle parts of the fjord (ca 25-100% increased primary production) indicating micronutrient fertilization. In summer, macronutrients were limiting throughout the fjord and the highest phytoplankton biomass was found at the sill indicating of advective transport of nutrients or phytoplankton biomass from outside the fjord or enhanced vertical mixing on top of the sill.

We suggest that micronutrient fertilization by subglacial meltwater inflow is an important mechanism fueling primary production in spring, while macronutrient limitation is more important in summer.

## **5410 Co-production of seamless sea-ice forecasting services around Svalbard**

**Cyril Palerme\***, Malte Müller

Norwegian Meteorological Institute

The hazardous sea-ice and weather conditions and the sparse telecommunication network experienced there, make the region a highly challenging operating environment leading to substantial business and environmental risks. Alone around Svalbard in 2018, the cruise traffic increased by 16% compared to the year before. Research and co-production of weather and sea-ice information services important to improve accessibility of polar regions and build the basis for sustainable business and social development.

We will present results from the SALIENSEAS (funded by JPI-Climate) and SvalNav (funded by Copernicus Environmental Marine Monitoring Service (CMEMS)) projects. Within SALIENSEAS we are working together with an international research team and end-users, such as Hurtigruten and The Norwegian Coastguard, to co-produce seamless sea-ice forecasting services. We utilize sea-ice charts, satellite retrievals, as well as, forecasts from the ECMWF seasonal forecasting system and the CMEMS Arctic Marine Forecasting Center. A strong focus is (1) to advance and combine those products by means of machine learning techniques, (2) to improve the accessibility by developing interactive mapping services, and (3) to give forecast reliability estimates based on new verification techniques. The SvalNav project is a CMEMS User Uptake project where we collaborate with the German company DriftNoise, in order to develop a web application which will allow to transmit high-resolution Sentinel 1 images to end-users (in a low-bandwidth format), in combination with sea-ice drift estimates based on sea-ice forecasts and post-processing. Thus, sea-ice information will be more accessible to a wide range of users operating around Svalbard. Both projects highlight the importance of co-production between researcher, intermediate-, and end-users.

## **5411 Past sea ice variations: reference values for a changing climate in Svalbard**

**Katrine Husum\***, Simon T. Belt, Ulysses Ninnemann, Dmitry Divine, Deniz Koseoglu, Anna Pienkowski, Lukas Smik, Kelly Hogan, Riko Noormets, Arto Miettinen

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During the last decades the Arctic cryosphere has been exposed to large climate changes, e.g. warmer waters entering the Arctic Ocean. Sea-ice cover is reduced and is going through a regime shift from thick perennial multiyear ice to an increasingly seasonal sea ice cover in the Arctic Ocean. Yet little is still known of the both the short- and long-term effects on the climate-ocean systems. Knowing the past sea conditions is important for establishing natural reference values in order to better understand the causes and consequences of current changes. In this study, we have reconstructed Holocene ocean temperatures and sea-ice reconstructions from the continental margin off northeastern Svalbard using fauna data and stable isotopes ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ) from benthic foraminifera in addition to sea-ice biomarkers, e.g. IP25 and HBI III. The results show that the sea ice decreases sharply during the Younger Dryas and is at a minimum at the beginning of the Holocene. The data also clearly shows that seasonal sea ice has been continuously present NE of Svalbard since the last ice age. The youngest data point in this study is from 1905, so this reconstruction does not show development over the last ca. 100 years. Trends in modern observations show that over the past 10 years seasons with relatively little sea ice are increasing in frequency. The geographical area of the sea ice cover is decreasing, and sea ice is disappearing earlier in the season than has been previously observed. The long-term historical reference values from this study indicate that the current sea ice situation may well resemble the conditions just after the last ice age (approximately 9500-9000 years before our time).

## **5412 A tale of two fjords: Holocene environmental changes in Dicksonfjorden and Woodfjorden, Spitsbergen**

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Fjord systems in the high latitudes host a complex suite of depositional processes controlled by climate changes, glaciers and sea ice, river networks, and sea-level changes. The fjords on Svalbard straddle an extreme environmental gradient between 1) the glaciers and seasonal sea ice inside the fjord and 2) the heat and nutrient flux of Atlantic Water intruding from the open ocean via the West Spitsbergen Current. Since the last deglaciation of the Svalbard-Barents Sea Ice Sheet, the Holocene period is marked by environmental fluctuations, including the early Holocene warmth followed by a subsequent stepwise regional cooling. Consequently, Svalbard fjords were influenced by a dynamic interplay of climate and oceanographic forcings throughout the Holocene.

Here, we investigate the Holocene environmental changes in Dicksonfjorden (central Spitsbergen) and Woodfjorden (northern Spitsbergen) based on multi-proxy analyses, including granulometry, mineralogy, and organic- and inorganic-geochemistry, of sediment cores. Unlike most other Svalbard fjords, tidewater glaciers are absent in Dicksonfjorden, where deposition occurs mostly by riverine input and sea ice rafting. Sediments are primarily supplied from the Devonian Old Red occupying most of the fjords drainage area, with minor input from upper Paleozoic carbonate deposits distributed around the fjord mouth. As one of the head tributaries of Isfjorden, Dicksonfjorden is hydrographically somewhat separated from the rest of the Isfjorden system. In contrast, the Woodfjorden system includes the main fjord and two tributary fjords, Bockfjorden and Liefdefjorden, and the latter currently hosts four tidewater glaciers. Because the glaciers in Woodfjorden overlie various types of bedrock, mineral composition of the fjord sediment probably reflect changing glacier activities. Moreover, Woodfjorden can be more readily influenced by Atlantic Water, owing to its proximity to the West Spitsbergen Current. We aim to further our understanding of the diverse depositional conditions in the Svalbard fjords and their response to the climate changes.

## **5413 The experience of using diatom analysis for paleo-environmental study on West Spitsbergen Island**

**Ksenia V. Poleshchuk\*, Sergey R. Verkulich, Zinaida V. Pushina**

Diatom analysis is widely used in paleogeographical and paleoenvironmental study. It is based on ecological characteristics of diatom algae species that's valves could be preserved in sediments. This method has special aspects of the use in the high-latitude Arctic: the species diversity provide sensibility to changes of such environmental characteristics as salinity, pH, water temperature, water depth etc. However, there is a few problems of diatom growth and preservation in the High Arctic, based on illumination weakness, dissolution in extremely cold water and terrigenous dilution by river flow.

Previous study on Svalbard that include diatom analysis are generally focused on lakes, besides very few methodological papers. Sediment outcrops are usually investigated using some other geomorphological methods but not the diatom analysis.

Our experience of four years complex paleogeographical study of quaternary sediments in river valleys and lakes of Svalbard includes diatom analysis has demonstrated some special aspects. The Sd-40, 2,5 meters' deep sediment outcrop in the valley of Dunderelva, contain marine sublittoral diatom complex that has shown trends to cooling and regression of relative sea level in the Early – Middle Holocene. Terrestrial outcrop GD-1 in the valley of Grøndalselva include Holocene freshwater diatom flora, that are correlate with diatom complex from other valley (Coleselva). Late Holocene environmental fluctuations are defined based on diatom flora of bottom sediment cores in Kongress lake. Nevertheless, there are many outcrops that gives no results using diatom analysis, that is connected with characteristics of diatom preservation and environmental features of valleys.

This background is necessitating the use of diatom analysis for paleogeographical study on Svalbard with attention to methodological aspects for understanding of diatom valves preservation.

## **5414 Results of a Svalbard-wide freshwater glacier discharge and plume model**

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Plumes, the upwelling of subglacial freshwater runoff emerging at the bases of tidewater glacier fronts, impact both the circulation of the fjord or ocean waters into which they emerge, and on the fjord or ocean ecosystem. Svalbard-wide runoff has been estimated using a coupled energy balance and snow/firn model forced with downscaled regional climate model fields covering the period 1957-2018, for both glacier- and land-covered areas in Svalbard. The model runoff is routed, either overland, using digital elevation models of the land surface, or subglacially, using Svalbard-wide ice thickness modelled with a mass conserving approach calibrated by ice-penetrating radar measurements, where available, to estimate the discharge through Svalbard tidewater glacier fronts. Modelled discharge is combined with fjord depth data and model seawater profiles of temperature and salinity to estimate the properties of plumes around Svalbard, using a numerical solution for a point-source plume released at the base of a vertical wall.

## **5415 Biomarker-based sea-ice reconstructions in the northern Barents Sea**

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The Nansen Legacy project, focused on the climate and ecosystem of the Barents Sea and adjacent Arctic Ocean, aims to provide an integrated perspective of the changing Arctic. One integral part of this project is the elucidation of the natural variability of sea ice and Atlantic Water inflow over longer (decadal to millennial) time scales, as a pre-requisite for accurate future climate projections. To contribute to this research focus, we here present preliminary data from marine palaeorecords



taken in a south-north transect east of the Svalbard archipelago. The three multicores consist of clay-rich mud and measure ~50 cm; they were analysed at 1 cm intervals for a range of highly-branched isoprenoid lipid biomarkers produced by sea-ice diatoms (IP<sub>25</sub>, IPSO<sub>25</sub>) and phytoplankton (HBI III, HBI IV). Collectively, these biomarkers can be used to reconstruct seasonal spring sea-ice regimes and the location of the seasonal sea-ice edge. Preliminary results indicate that all three cores contain abundant biomarkers; pending total organic carbon (TOC) results from the cores will allow the normalization of biomarker concentrations to TOC and inter-core comparisons. The southernmost site, NPAL04, taken in southern Olga Strait, shows the most dynamic biomarker profile, with preliminary sea-ice reconstruction indicating a pronounced decrease in seasonal sea-ice in the upper 10 cm of the core. Pending radiocarbon dates on all cores will permit placement of these changes into a chronological context, in turn allowing for comparisons between cores and existing records.

## **5418 Mid- and Late Holocene vegetation inferred from pollen record of Northern Nordenskiöld Land peat sequences (West Spitsbergen Island)**

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The pollen and radiocarbon data newly obtained for two peat sequences from the Coles valley (Spitsbergen Archipelago) allow us to reveal several stages of vegetation development during the Holocene. A comparison of these data with our previous data from Grendalen valley and published data from north cost of Nordenskiöld Land shows the asynchronous of vegetation development on these area from ~5000 to ~2500 yrs ago. Probably this event is connected with the orographic features and distance far from the ocean. The model of vegetation changes for the north part of Nordenskiöld Land on the basis of pollen and radiocarbon data will be presented.

## **5419 Cryoconites - as a source of carbon for soils and soil-like bodies developed under conditions of rapidly retreating Arctic glaciers (for example Aldegonda glacier, Svalbard)**

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Recent climate warming has caused rapid thawing of Arctic glaciers and the development of soil-forming processes on freshly exposed substrates. Sediments that have accumulated over the lifetime of these glaciers have mostly aeolian genesis and include both minerogenic and biogenic components. Such sediments are termed cryoconites. The retreat of glaciers is accompanied by the release of cryoconite material into water flows that carry and deposit such material usually within areas sheltered from winds. In comparison to other deposits within the modern periglacial zone of the Arctic, the cryoconite parent material of soils has special properties, which favour the colonization by higher plants and the development of pedogenesis. The study sites were located within the glacio-nival system of the rapidly retreating Aldegonda Glacier (its snout was reduced by 2 km in the last 100 years) and on third marine terraces of the East-Fjord in Svalbard, Norway (77.98 N, 14.11 S). A complex of modern instrumental methods they are radiocarbon AMS dating, isotope mass-spectrometry, <sup>13</sup>C-NMR, and traditional physico-chemical and morphological methods of

research were applied. On the basis of isotope, chemical and morphological analyses, it was revealed that the cryoconite material is the primary carbon source for soil organic matter (SOM) on the moraines studied. Judging from the radiocarbon dates, the cryoconite material is supplied because of rapid melting of deep layers of the glacier. The morphological features of cryoconite material are preserved for several decades within the soils studied, with cryogenic differentiation being the main process of reorganization of mineral mass and the organic matter being inherited from cryoconites. Therefore, soils with well-developed profiles, rich in biogenic elements are formed on the cryoconite material within a period of first few decades. In the absence of cryoconite material in similar geomorphological situations, a period of a few hundred years would be required for the formation of similar soil profiles. The study was supported by RFBR grant 17-04-01475 and state assignments 0148-2017-0005.

Keywords: cryoconite, soil-forming processes, soil organic matter, glacier

## **5420 Implications of Terrestrial Inputs for the Optical Characteristics of DOM in an Arctic Fjord System**

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Dissolved organic matter (DOM) is a key component in the global carbon cycle. In coastal areas, it can be produced within the water column as a result of 'leaky' photosynthesis and phytoplankton cell lysis (autochthonous DOM), or can be transported from the terrestrial environment (allochthonous DOM) via glacial melt and riverine run-off. The source of DOM, which can be determined by the characterization of its absorption spectra, provides an indication of the degree to which it can be utilized by coastal microbial food-webs.

Warming temperatures are predicted to lead to increased river run-off to coastal ecosystems. In addition to allochthonous DOM, these inputs bring freshwater, sediments and nutrients across the land-ocean interface, which affect autochthonous production of DOM in the water column due to increased stratification and light attenuation. To investigate how these physicochemical characteristics of freshwater run-off change seasonally, with implications for the source and bioavailability of the DOM pool, 17 stations were sampled in May, June and August in Isfjorden, Svalbard in the summer of 2018. Using redundancy analysis, we explore the relationships between nutrients, light, chlorophyll a and their impact on the quantity and quality of DOM and how these relationships shift seasonally and spatially along the freshwater to marine gradient.

The freshwater footprint in Isfjorden was characterized by increased light attenuation and dissolved nutrients, as well as substantial concentrations of allochthonous DOM, especially in June. Based on analysis of the optical properties of DOM, we propose that physical and biological processing of allochthonous DOM through the summer months is an effective degradation pathway, shifting it from high to low molecular weight and thus making it more bioavailable to the microbial loop.

## **5423 Recent progress in Svalbard coastal change research – advances and remaining questions**

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During the last century, the landscapes of Svalbard have experienced a major change from a glacial towards a paraglacial domain as a consequence of widespread glacier retreat and the extensive reworking of glacial sediments by nonglacial geomorphological processes. To date, relatively little information exists regarding the impact of such a profound glacial landscape transformation on the evolution of coastal environment. In this paper we address this deficiency by reviewing the recent progress in coastal change studies in Svalbard. We report here, the most up to date information on the functioning of Svalbard coastal zone along both accumulative and rocky sections. The new data collected from rapidly deglaciating fjords of Svalbard suggest very sensitive reaction of beach systems to the post-Little Ice Age sediment fluxes. Progradation of coastal landforms (e.g. tidal flats, deltas, spits, barriers) is mostly associated with development of new sediment routing systems operated by (glacio-)fluvial, slope and permafrost processes. However, shortening of sea-ice period duration, increasing number of storms hitting the coasts and shifts in sediment delivery systems have also led to periods of intensified erosion threatening numerous Svalbard heritage sites and coastal infrastructure. We also demonstrate that the rocky coastal systems exposed from glacier ice over the Holocene, and during the modern phase of accelerated climate warming, are changing the way they interact with cryosphere and sea waters. Finally, we discuss the differences in the coastal responses between various regions of Svalbard including the new ‘tipping point’ of southern Spitsbergen, which due to the ongoing collapse of glacier system is about to become new island of the archipelago.

## **5424 Microbial methane cycling during the Holocene in Svalbard: a paleogenomics perspective based on lake sediment**

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Arctic landmasses and lakes release significant amounts of methane (CH<sub>4</sub>), a greenhouse gas with an atmospheric warming potential 25 times higher than CO<sub>2</sub> that contributes heavily to global climate change. Yet the effect of rapid warming in the Arctic on the long-term fate of natural CH<sub>4</sub> emissions from lakes is poorly understood. Lake sediment provide a vertically structured window into past interactions between microorganisms and their environments, and in cold climates provide some of the best preservation conditions for ancient DNA. Here we use paleogenomic techniques on lake sediment to track the establishment and dynamics of microbial communities in the Arctic landscapes of Svalbard, with a particular focus on the sensitivity of CH<sub>4</sub>-processing microorganisms and competitors to climate change over the Holocene period (last 11,700 years). For the first time, ancient microbial metagenomic profiles are extracted from Svalbard lake records to determine the

effect of centennial to millennial climate change on this potentially important yet understudied greenhouse-related biogeochemical process.

## **5425 Weather events affect the removal and dispersal of invertebrates in supraglacial zone – case study from Longyearbreen**

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As frozen water on land, glaciers are unique inland systems which host characteristic biotic assemblages. The knowledge of glacial ecosystems is, however, still limited and although data are available regarding the diversity of microbial assemblages inhabiting the surface of the ice, little is known about how their population varies in time. The main aim of our research was to investigate links between changes in weather conditions and short temporal changes in invertebrate densities on glaciers. Cryoconite holes constitute natural, simple and dynamic habitats in a glacial biome and, as such, were chosen as suitable ecosystems for conducting such observations. As model organisms for tracking changes in cryoconite holes, we used top consumers on Arctic glaciers, mainly water bears (Tardigrada) and rotifers (Rotifera). Our study was conducted in August 2016 on Longyearbreen.

During sampling campaigns, we observed freezing, shrinking and ablation of cryoconite holes. Invertebrates were present inside them until calm weather was interrupted by wind and rainstorms. Before such events, densities in the samples reached 149 tardigrades and 119 rotifers per 1 cm<sup>3</sup> of a cryoconite. Afterwards, no individuals were detected. In addition, we noticed strong erosion of cryoconite granules, redistribution into fine sediments, and migration of granules after rain, which confirmed that invertebrates were mechanically removed by streaming water. During our investigation, we measured water depth, pH and electrical conductivity, but there is no evidence that these parameters affect invertebrate communities. Their frequency and densities on valley glaciers depend on stochastic events, such as weather breakdowns (rainstorms). Furthermore, such events may form new niches for tardigrades and rotifers on polar glaciers and influence their coexistence within cryoconite holes.

The field works and laboratory analysis were supported by the National Science Center grant no. NCN 2013/11/N/NZ8/00597 and by the Ministry of Science and Higher Education of Poland No 3841/E-41/S/2018.

## **5426 Assessing the effects of rain-on-snow events on soil conditions – a modelling approach**

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UiO; UNIS; NTNU; MET.no

Ground icing due to rain-on-snow events is a widely observed phenomena across the Svalbard tundra, with broad implications through e.g. permafrost warming, effects on the snow-pack, and ice-locked herbivore pastures. As the winters in Svalbard are projected to be warmer and rainier in the

future, it is of increasing importance to understand and predict the extent and effects of icing events. In this MSc project, the processes leading to ground ice formation in response to rain-on-snow events and wintertime warm spells are addressed. We aim to do this by running several realizations of physically based snow/ground models in parallel, allowing for lateral exchange of water in liquid and frozen (snow) form. Our model setup allows for representation of both the vertical and horizontal aspects of ground ice formation, including both small-scale interactions between liquid water and individual layers of the snowpack, and how the water is redistributed laterally in the terrain. The schemes are forced by weather forecasting data, and each parallel run represents a distinct topographic element. Such an approach captures how local topography influences lateral water percolation within the snowpack, bridging the gap between gridded weather data and field observations. The approach is validated against field observations from Bayelva catchment nearby Ny-Ålesund, where 7 years of data of snow depths and basal ice thickness have been sampled at >100 points within 0.5 km<sup>2</sup>. This approach can be applied where basic information on topography and reliable weather data is available, and once validated, it can be used to assess the extent and distribution of ice locked pastures, the effect of rain-on-snow on soil temperature, and the differential snowmelt across terrain features.

## **5427 Svalbard as a key to ichthyosaur evolution**

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Ichthyosaurs were marine reptiles pursuing their prey in the Mesozoic seas (?250-100 million years ago). Due to their long history and fossils from the entire globe, they are ideal for research on the dynamics of marine ecosystems, and Svalbard is unequalled worldwide in terms of marine fossil deposits from some of the critical periods in ichthyosaur evolution.

Bonebed excavations have resulted in more than 35 000 fossils documenting the entire ecosystem in the recovery phase after the Permian-Triassic mass extinction. Ichthyosaurs originated and transitioned to the marine realm probably directly after this event, but this is poorly documented. Threedimensional fossils of early ichthyosaurs and close relatives from the Early Triassic on Spitsbergen challenge conclusions drawn on the basis of Chinese localities and give insight into early ichthyosaur radiations and the evolution of live birth underwater.

During the Triassic and Early Jurassic, ichthyosaur diversified, before encountering extinction events leaving one major lineage, the ophthalmosaurids, in the Late Jurassic and through to their mysterious disappearance in the Cretaceous. Research on 26 specimens from the Late Jurassic-Early Cretaceous deposits of the Slottsmøya Member Lagerstätte demonstrates a high diversity ophthalmosaurid assemblage with new taxa closely related to contemporaneous species from other high latitude localities.

The high number of stratigraphically well-constrained fossil specimens from several time periods on Spitsbergen also increases our understanding of skeletal adaptations to a marine life. Adaptations in the fore- and hindfins, pectoral and pelvic girdle from the Triassic to the Cretaceous show that ichthyosaurs changed their swimming mode and only partly followed a convergent evolutionary trajectory compared to other secondary marine vertebrates such as whales.

## **5428 Hydroclimatic reconstruction from annually laminated proglacial lake sediments, Linnévatnet, Svalbard**

**Mike Retelle\* (1,2), François Lapointe (3), Ray Bradley (3)**

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In Svalbard, periods of intense rainfall, associated with warm sea surface temperatures and declining sea ice cover, now occur during all seasons with the greatest increases seen in fall and winter. We present new results from Linnévatnet, where laminated sediments are used to reconstruct the long-term history of rainfall-related sedimentary events, and specifically to determine when similar autumn “shoulder season” conditions may have prevailed in the past. Over the period 2003-2009, sediment trap analysis reveals that, peak river discharge from 2003 to 2010 occurred during the spring-summer nival flood, while in 6 of the past 8 years peak flow and sedimentation occurred during late summer early fall rain storms.

Analysis of ~ 1000 scanning electron microscope images from thin sections from a sediment core recovered in 2018 and processed to extract annual grain-size and varve thickness (VT) for the past ~900 years. Results show that thicknesses from the adjacent sediment traps collected over the past 14 years compare well with VT and the 50th percentile  $\mu\text{m}$  (D50) from the sediment core ( $r = 0.70$ ,  $p = 0.005$ ). Since rainfall dataset at Isfjord Radio, the weather station located nearby Linnévatnet (6 km), is scarce and limited, we combined data from Green Harbour and Isfjord Radio to provide a relative long-term rainfall dataset. Correlation between sediment properties at Linnévatnet with rainfall is best achieved during shoulder season, that is coherent with field work monitoring: D50 and  $\mu\text{-XRF Ca}$  at Linnévatnet is correlated to August - October rainfall ( $r = 0.60$ ,  $p = 0.001$ ). Over the instrumental period and during the past 900 years, the year 2016 is characterized by the sharpest increase in D50 corresponding to the heaviest rainfall recorded by observations. This suggests that this event is unprecedented, and potentially a signal of a new hydrological shift at Svalbard.

## **5429 Influence of Natural Factors on Permafrost Stability on Svalbard in the 21st Century**

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One of the components of the natural environment of Svalbard is the permafrost. Its degradation can lead to negative phenomena, both for the natural environment, and for engineering structures and communications due to the loss of strength of the foundations of structures and activation of slope processes. The loss of stability of permafrost is caused by the formation of non-merging permafrost transient to talik. This occurs with incomplete freezing of the seasonally thawed layer due to climatic changes and variability of the surface cover and soil parameters.

The formation of non-merging permafrost is due to both climatic changes and a number of natural factors affecting the soil thermal regime. The influence of the snow and moss cover parameters on the temperature regime, soil freezing and melting, both separately and in combination with climatic changes, is considered. The studies show the need for interdisciplinary research (glaciological,

botanical, climatic, soil) on the effect of climatic changes on the parameters and thermal characteristics of the snow cover, vegetation and soil.

To determine the time of the beginning of the formation of non-merging permafrost under current climatic changes, calculations were made on the mathematical model. For calculations, the forecast values of air temperature from the global and regional climate models were used. The time of the beginning of the formation of non-merging permafrost is determined depending on the thickness of snow and moss cover, and soil moisture content.

This study was supported by grant RFBR No 18-05-60067, field studies on Svalbard were conducted with financial support from the state assignment 0148-2017-0005 and logistical assistance of the Russian Scientific Center on Spitsbergen (RSCS).

## **5430 Coal – the ice core of the warm past – developing a knowledge resource on Svalbard for high resolution palaeoclimate research**

**Maria Jensen\* (1), Malte Jochmann (1,2), Chris Marshall (3), Anna Stella Gudmundsdottir (1), Olaf Lenz (4), David Large (3)**

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Paleocene coal from the Firkanten Formation, Svalbard were deposited as peat c. 61 mio years ago. During deposition, Svalbard was located at approximately the same latitude as today, but in a warm world without polar ice caps (Piepjohn et al 2016; Zachos et al., 2001). Atmospheric CO<sub>2</sub> levels during the Paleocene were higher than present and comparable to changes expected to happen during this century (Zachos et al. 2008). No modern analogues exist for polar environments with rich vegetation and polar night, so past environments are important windows into possible scenarios for Svalbard and the Arctic in a warmer future.

Like ice cores and deep marine drillings, peat (coal) represents a relatively undisturbed environment from which geochemical signatures of climate change can be extracted. High resolution inorganic geochemical data from coal seams are known to record circulation patterns, dust deposition rates, (atmospheric nutrient supply), wildfires, provenance and its response to changing climate (Marshall et al., 2016). A pilot study of the 1,4 meter thick Longyear seam of Mine 7 was carried out by Marshall (2013), and is interpreted as representing continuous deposition for 90 000 – 100 000 years. The up to 5 m thick Svea seam may represent up to 400.000-500.000 years. Analyses of the section in mine 7 showed several levels of increased content of fossil charcoal, probably derived from forest fires in the moor land, alternating with aluminum-enriched layers, suggesting dry periods.

We have sampled complete coal seam successions from the Lunckefjell mine before it was closed in spring 2019 and will sample the complete succession from Svea Nord in fall 2019. All samples from the closed mines will be archived and form the basis for high resolution palaeoclimate research at UNIS in the coming years. We will present this and discuss new results from Mine 7.

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## **5431 Terrestrial inputs as a key driver of Arctic coastal biogeochemistry, ecology, and contamination**

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(1) NIVA

Arctic ecosystems are in transition, with multiple (often inter-related) stressors driving long-term environmental change. Stressors such as climate change (thawing permafrost, melting glaciers, changes in precipitation and runoff patterns) and human activity resulting in land-use changes can lead to altered fluxes of water, nutrients, and contaminants across the land-ocean interface. These changes will have strong effects on coastal ecosystems, highlighting the importance of understanding the transport, transformation and fate of terrestrial inputs, and their effects on local, regional and global biogeochemical cycles, coastal ecology, and contamination of coastal ecosystems.

Despite the biogeochemical and ecological importance of the Arctic coastal zone, key processes and interactions at the land-ocean interface remain relatively poorly understood, perhaps due to the spatially and seasonally dynamic boundaries between terrestrial, freshwater, and marine ecosystems. This lack of detailed knowledge makes it difficult to assess the potential local, regional and global impacts of projected future changes in fluxes of freshwater and associated solids and solutes from land to sea.

Here I present results from the TerrACE project, an interdisciplinary project involving a broad range of Norwegian and international partners that focuses on generating quantitative information about terrestrial inputs to coastal waters in Svalbard, and how these inputs affect coastal biogeochemistry, ecology and accumulation of environmental contaminants in biota. Based on extensive field sampling in Isfjorden, Svalbard (carried out in summer 2018), we have generated key baseline data regarding effects of riverine and glacial inputs on coastal water and sediment chemistry, benthic and pelagic community structure, food web interactions, and contaminant cycling.

## **5434 Lake sediments with Azorean tephra reveal unglaciated areas existed on coastal northwest Spitsbergen during Last Glacial Maximum**

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Variations in the extent and style of past glaciation yield key insights into the future behavior of Earth's rapidly changing cryosphere, the main driver of global sea-level rise. Lake sediments retrieved from the beds of former non-erosive ice sheets offer unique possibilities to constrain these changes



and place them in an absolutely dated context. Here, we present the first pre-Holocene lake sediments reported from Svalbard. Radiocarbon dating of terrestrial mosses reveal that the investigated lowland catchment on Northwest Spitsbergen was unglaciated and vegetated between 30-20 ka BP, coincident with the global Last Glacial Maximum (LGM). The presence of a geochemically homogenous and previously undiscovered volcanic ash marker from a contemporaneous eruption on the Mid-Atlantic Azores archipelago provides additional evidence for ice-free conditions. Stratigraphic indicators of sediment compaction and a depositional hiatus suggest that the basin was subsequently overridden by non-erosive (cold-based) ice from 20-11 ka BP. These findings challenge existing views on the glacial history of Svalbard and raise the possibility that plants endured the Last Glacial period here. Also, comparison with paleoclimate reconstructions from the region indicate that sea-ice variability controlled this pattern of ice-sheet evolution by modulating moisture supply (accumulation). This interpretation underscores the importance of hydrological change for the evolution of Arctic Ice Sheets, which face a future that will be warmer as well as wetter.

<sup>1</sup> throughout the abstract the word 'petroleum' is used as a collective term for hydrocarbons and includes both oil and natural gas.

<sup>2</sup> Arctic5 is five littoral countries Canada, Denmark (Greenland), Norway, Russia, the US.

## **6001 The next generation of Polar scientists**

**Pernille Bronken Eidesen\***

The University Centre in Svalbard

The climate is changing, and the changes are most severe in polar areas. As a consequence, we as Polar scientists focus our research towards topics related to climate change. Likewise, we teach our students about causes and consequences of climate change. We introduce them to the extensive body of research available, the uncertainties, and the unsolved problems. But discipline knowledge is not enough. We need to understand that current facts soon are old news, and not relevant for future scientists. We need to focus our education towards how to find up-to-date knowledge, how to evaluate the quality of knowledge, how to generate new knowledge, and how to communicate the findings – to peers, to politicians, and to the society. To understand climate change, scientific research programs bridging traditional disciplinary boundaries have been essential, but a need for even closer cooperation is predicted. Thus, to reduce current knowledge gaps, our students need to develop cooperation skills, including respect and understanding for an interdisciplinary and international research community. Furthermore, we have the responsibility to prepare our students for a world that is different from the one we know. To cope with changes, we need to provide the next generation of Polar scientists with problem-solving skills, like creativity, critical thinking, engagement and responsibility. To gain such skills, students need authentic practice outside the lecture room. We have a common responsibility to facilitate such practice, and several funding schemes for educational cooperation exist, but I question whether we utilize their full potential.